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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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THE IMPORTANT PILING TIMBERS OF AUSTRALASIA.

By A. K. Armstrong.*

Frequent mention has been made of Australian woods as piling timbers, especially where the depredations of marine wood-borers are to be resisted. The woods most frequently spoken of are the turpentine-tree (*Syncarpia laurifolia*), those species of eucalypti known as "ironbarks," jarrah (*E. marginata*), blue gum (*E. globulus*), and stringybark or Tasmanian oak (*E. obliqua*), and totara (*Podocarpus totara*).

Practically all that has been published relative to these timbers, both in the United States and abroad, is too widely scattered to be readily available. The Forest Service, therefore, undertook the collecting of this information, and to it has been added data obtained through correspondence with engineers in all portions of the world. This paper is a summary of the material obtained on the species mentioned, and represents the experience of various engineers and others as reported by them.

The turpentine-tree (*Syncarpia laurifolia*), which is not a eucalyptus, is a native of north-eastern Australia. Its wood is hard, but apt to shrink and warp unless well seasoned. It is durable under trying conditions, and reputed to be very non-inflammable. Its green weight is about 69 lb. per cub. ft., and its seasoned weight about 57 lb. Julius† gives the modulus of rupture with per cent. moisture (air-dry) as 15,710 lb. per square inch, the crushing strength in end compression as 8,950 lb. per square inch, and the shearing strength as 1,730 lb. per square inch.

According to Maiden and De Coque‡ there are two varieties of the turpentine-tree, the black and the red. The former is, in most cases, over-matured timber, in others, the product of trees injured or marred in growth. The red is thoroughly sound and full of life. In some districts it is recognised that the bark of the red turpentine is tougher, and the oleoresin more abundant than that of the black. Red turpentine is generally called for in specifications covering piling.

The red turpentine is supposed to resist the attacks of the marine wood-borers, a property attributed to a layer of oleoresin distasteful to those organisms between the bark and the wood. The use of squared piles is, however, frequent. Their sapwood is soon destroyed, but the heart is apparently more or less resistant to attack. The best results are secured upon piles with the bark intact.

Trees to be converted into piles with the bark on are cut in the summer. The bark at that season clings to the log and is not so liable to start when felling. If cut in the winter when the sap is down, the bark is readily separable. Nevertheless, even with the greatest care it is practically impossible to procure and drive any number of piles without injuring the bark. The falling of the tree, its handling from the stump to the wharf, loading in and unloading from the ship, and the impact of the pile hammer, all tend to injure the bark. Maiden and De Coque observed that in stacks of piles intended for the use of the New South Wales Government, not one held its bark intact. The latter investigators concluded that turpentine, barked or unbarked, is not absolutely proof against the marine wood-borers, either in pure salt or tidal waters; especially in the latter, where salt and fresh water mix. They recommended that the future use of turpentine be discontinued, unless thoroughly sheathed, except in pure salt water where the Australian borers (species of Nausitoria) were not active, and in pure salt water where they could not exist. Turpentine is, however, used almost entirely unsheathed, though the attempt is made to keep the bark intact.

The following specifications were drawn up for the supply and delivery of turpentine piles at the Port Kembla jetty of the New South Wales Government:—

"Immediately tenders have been accepted the trees from which the piles are to be taken must be ring-barked, but not felled for at least four weeks thereafter, the greatest care being taken not to injure the bark. The bark at the ends must be bound with hoop iron.

"Piles must be allowed to remain in the bush for at least two weeks, or such time as the engineer may decide upon, before removal.

"Piles must be perfectly sound, free from all defects, to measure not less than 18 in. in diameter at the head and 15 in. at the toe, exclusive of bark, and to be of the lengths ordered.

"Piles will be inspected at the port of shipment, if so desired by the contractor, but should the engineer, or his responsible officers, find that the piles have become damaged or rendered unfit for use through neglect on the part of the contractor to properly stack and protect them during transit or before delivery is taken at Port Kembla, the piles found so defective shall be liable to condemnation, and the contractor shall replace the piles so condemned at his entire cost and expense. Final inspection will be made at Port Kembla."

For a wharf at New Castle, New South Wales, the specifications were that:—

"Piles shall be of turpentine, driven with the bark on."

The necessity for keeping the bark intact is recognised by the Auckland (New Zealand) Harbour Board. Fender piles up to 74 ft. long and 18 in. in diameter are used. Round piles, with the bark intact, are specified. The timber must be free from shakes and other defects. The Harbour Board has the timber shipped to them inspected by the Forest Department of New South Wales.

The Japanese engineers have used both barked and unbarked red turpentine piles at Yokohama, Kobe, and Kelun (Formosa). The specifications for the Yokohama harbour work called for the timber to be hard, strong, free from splitting, decay, bends, and other defects. Rounding in the side edges (or wane), if present, had "to be under 3 in.," and the piles were to be perfectly square. These squared piles (with the bark removed) did not prove very resistant to the marine wood-borers (shipworm, limnoria, and chelura); and the same was true with the round piles with the bark on used at Kobe.

Turpentine, compared with Douglas fir, has much less taper than the latter, so that in great lengths turpentine will not give a top diameter approaching that of the fir. It is very brittle, almost too much so to be used for fender piling. On account of its heaviness it is necessary to keep the piles in a scow instead of floating them. This is also true of the other species described below. In driving turpentine requires more careful handling than Douglas fir.

The accounts of the life of turpentine piles show considerable variation. At Sydney harbour, after a long experience with turpentine, the same species was used for renewals. The new ones were 4,640 in number, ranging from 40 to 80 ft. in length, and the engineer in charge was confident that they would give 30 to 35 years' service. However, the New South Wales authorities do not claim that turpentine is immune from the attacks of the marine wood-borers, but they do assert that, with the bark intact, it is the only timber they dare drive unprotected by sheathing. Under the precautions observed it evidently gives satisfaction in those waters.

In 1907 it was reported from Durban, South Africa, that while turpentine was thought equal, if not superior to jarrah, it was not considered immune, and for that reason the authorities were turning to the use of concrete.

Turpentine piles 70 ft. long and from 12 to 14 in. square were driven by the Canadian Pacific Railway from 20 to 25 years ago, and are reported to be still in service at Vancouver, British Columbia. According to the reports on hand, Douglas fir in the same locality is destroyed by the shipworm and limnoria in from 12 to 18 months. There are, however, many instances given where turpentine has been destroyed in a much shorter time than 20 years. Like most pile timbers, it seems to give the best service in waters contiguous to its habitat, possibly because the methods of handling it are there best understood.

Another species of *Syncarpia*, botanically known as *Syncarpia hilli*, and by the native blacks as "peabeen," grows in North Queensland. Its wood is close-grained and tough, and the bark is said to contain a considerable amount of tannic acid. It lacks the clear straight trunk and accessibility of turpentine, for which reasons it has not been employed for piling.

The substitution of other species for turpentine is not likely to take place, since it is the cheapest of the New South Wales hardwoods procurable in the round, and is plentiful in the coast districts.

The Ironbarks.—The ironbarks belong to the genus *Eucalyptus*, and, like all eucalypts, the portion nearest the pith or centre of the tree is the weakest part of the timber; when used for piles they should have the heart boxed; where cut for scantlings, the latter should be clear of the pith by at least 3 or 4 in.

The name "ironbark" is commonly applied to six species of the genus *Eucalyptus*, and less frequently to two others. The adjectives of colour generally applied to the "ironbarks" are indiscriminately used, and unless the botanical name is appended it is often difficult to discover what particular species is meant.

Eucalyptus crebra is known as "grey," "white," "red," or "narrow-leaved ironbark," and "grey gum." The specific gravity of the wood (probably green) is given as from 1.119 to 1.211.

Eucalyptus paniculati is the true "white ironbark" of eastern Australia. It is also known as "red," "pale," or "she ironbark," and "bloodwood." Its weight per cubic foot is given at from 71 to 76 lb. (probably green). It is probably the most durable of the ironbarks. According to De Coque* it is a comparatively rare timber. It was formerly used at Auckland, New Zealand, but unless sheathed with metal was rapidly attacked.

Eucalyptus siderophloia was formerly designated as *Eucalyptus resinifera*. It is known as "red, "dark red," "dark," "grey," and "broad-leaved ironbark." Its weight per cubic foot varies from 64 to 71.5 lb. The timber is liable to heart and star-shake. The Harbours and Rivers Department of Queensland specifies piles of this species to be truly straight and sound throughout, free from piping, decay, knots, wanes, or other imperfections. The piles must measure not less than 16 in. at the butt, and 12 in. at the small end, when dressed clear of all sap.

Eucalyptus sideroxylon is known as "red ironbark." According to Boulger (see his book on "Wood") it is an allied form of *Eucalyptus leucoxylon*; but the wood is darker and heavier. Its modulus of rupture (moisture content unknown) is given at 16,300 lb. per square inch. It has been planted in South Africa and California, but does not seem to thrive in the United States. It is more resistant to the shipworm and limnoria than the blue gum (*Eucalyptus globulus*), manna gum (*Eucalyptus viminalis*), and grey gum (*Eucalyptus tereticornis*) grown in the United States.

Eucalyptus leucoxylon is known as "red," "white," "grey," and "black ironbark," "black mountain ash," and "white," "bastard," and "scribbly blue gum." Its weight per cubic foot varies from 63.5 to 73.3 lb. Piles, girders, &c., up to 60 or 70 ft. long are produced from this species, which, in New South Wales, is apparently more plentiful than the other ironbarks. Its modulus of rupture is given at 17,900 lb. per square in. (moisture content not given).

Eucalyptus sieberiana is known in Tasmania as "bastard," or "white ironbark," "silvertop," "greentop," "blackbutt" and "cabbage gum," in New South Wales as "mountain ash" and "gum-top ironbark," and in Victoria as "silver top" or "bastard ironbark," "white ironwood," and "Gippsland mountain ash." Its weight per cubic foot varies from 55 to 60 lb. It is an inferior timber, full of gum veins, seasons badly, is generally soft, and doubtfully durable. In Tasmania it seems to

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† "Western Australian Timber Tests," 1906. Gov. Publ., Perth, W.A.

‡ "Report on Turpentine Timber, &c." Gov. Publ., Sydney, 1895.

* "Timbers of New South Wales." Journal and Proceedings, Royal Soc. of N.S.W., 1894.

be considered as good as blue gum for piling, but is scarce and not to be obtained within reach of a shipping port.

The ironbarks are readily attacked by the shipworm, but are largely used in Australasian waters, since, if properly sheathed, they are the most durable and strongest of all the timbers of that region. Up to the end of 1888 the Harbour Board of Dunedin, New Zealand, constructed 4,520 ft. of wharves, in which ironbark was generally employed. Parallel instances might be given for many of the Australian ports; though in every case metal sheathings are used to protect the piles. The one notable exception is Melbourne, where the almost entire absence of borers from the port renders sheathing unnecessary. It is estimated that at Sydney any sheathing used will double the cost of a pile. Muntz metal is most widely employed for sheathing purposes, but owing to the failure of that metal in recent years, naval brass is coming into vogue.

Jarrah (*Eucalyptus marginata*) is known also as "mahogany" and "bastard" or "Swan River mahogany." It grows in Western Australia, where its forests cover between 12,000 and 14,000 square miles, in a mixture, however, with other species.

Jarrah gives clear lengths of from 50 to 60 ft., and it is not uncommon to obtain timber from 20 to 40 ft. long and from 1 to 2 ft. square. It weighs 68 lb. per cubic foot when green and 55 lb. dry. At 12 per cent. moisture (air-dry) its modulus of rupture is 15,000 lb. per square inch, its shearing strength 2,010 lb. per square inch, and its strength in end compression 9,050 lb. per square inch. Jarrah, when severely punished in driving, is liable to spilt longitudinally.

Jarrah has no knots or gum veins, but tends to pipe at the heart. It occasionally suffers from decay at the heart, but not on the outside, where the timber is strongest. In water infested by the marine wood-borers the sapwood on round timber seems non-resistant.

Jarrah seems to be very inflammable. It also contains from 16 to 20 per cent. of powerfully astringent gum, mainly consisting of acid closely allied to tannic. Du Cane* found this gum, which was poisonous to mice, in the heart-wood of sound trees which had proved resistant to the marine wood-borers and white ants, but absent from decayed and defective timber which had proved non-resistant.

The safest assurance of receiving sound jarrah when specified is to have inspection made by the Government of Western Australia. For 3*d.* per 100 super. ft., all timber shipped is guaranteed of the right species and good quality. This is indicated by brands stamped on the end of every log. Another fair assurance of proper identification is the port of shipment, since jarrah is only exported from Fremantle, Rockingham, and Banbury.

Jarrah can vary widely in durability and resistance. Conditions of growth affect its properties. The best timber is found among the rocky boulders on the summits of the granite and ironstone ridges of its habitat. Trees grown on the sandy plains near the sea yield inferior timbers, twisted, shorter in the grain, and less durable.

The timber should be cut when the sap is at the lowest ebb. If round, it should be banded as soon as felled. If square, the practice seems to be to season it one month for every inch of thickness. However, in piling, the value of seasoning is largely problematical, since it is not known what effect seasoning may have upon the gum content. To the latter the resistance of the timber to the marine wood-borers may be attributed.

In 1894 jarrah cost in England (the demand being slight and the timber consequently imported in small quantities) about 5*s.* per cubic foot. In 1904 jarrah, in South Africa, brought from 2*s.* 4*d.* to 3*s.* per cubic foot, or a little more than longleaf pine. In 1908 the price in England was 7*l.* per ton, which, based on its dry weight of 55 lb. per cubic foot, was equivalent to 3*s.* 10½*d.* per cubic foot. The freight alone amounted to 50*s.* or 60*s.* a ton.

Jarrah obtained its high reputation in Western Australia. In 1901 jarrah was exclusively employed there for piling. In 1906 the Ministry of Lands and Agriculture* reported that in temperate zone waters jarrah did not suffer visible injury from the marine wood-borers, frequently lasting over 30 years, but in tropical waters it was necessary to sheathe the timber with Muntz metal. This would probably mean that if jarrah was used in American waters it would have to be sheathed south of Norfolk, Virginia, and San Francisco, California.

In 1901 jarrah was employed in the jetties of South Australia, but was not considered proof against the shipworm. Jarrah is recommended for use in the harbour works of Melbourne, where the marine wood-borers are absent or scarce. Jarrah, when used at Sydney, is sheathed with Muntz metal or reinforced concrete.

Jarrah piles at Auckland, New Zealand, must be protected. The engineer of the Wellington, N.Z., Harbour Board reports jarrah as resisting the marine wood-borers better than ironbark.

In 1904 F. W. Waldron† reported for South Africa that jarrah gives the best results.

Jarrah was first used in the English Channel 20 years ago, and is now coming into vogue in England, probably because it is much cheaper than Demerara greenheart. The Great Central Railway reports that the cost of jarrah, however, prohibits its general use, but that it is employed by them in the construction of piers in tidal waters. At Cork (Queenstown), Ireland, jarrah is replacing greenheart in the outer harbour, where the shipworm and limnoria are bad. Its lower first cost is given as the reason for its substitution. The Dutch Government, after experimenting, prefers Demerara greenheart to jarrah in waters infested by the shipworm. The Canadian Pacific Railway has driven jarrah piling in the waters of British Columbia, and they seem to be giving excellent service.

Probably jarrah has suffered in reputation by the substitution of karri (*Eucalyptus diversicolor*). Both timbers grow in the same region and look much alike in the log. Karri is stronger and drives better than jarrah, but (probably owing to the absence of the astringent gum before mentioned) is not resistant to the marine wood-borers. Its price is about the same as that of jarrah, but it can be obtained in larger sizes.

Blue gum (*Eucalyptus globulus*) and stringy-bark (*Eucalyptus obliqua*) will be considered together. *Eucalyptus obliqua* is also known as "Tasmanian oak," "black," and "ironbark box" in Tasmania, and as "messmate" in Victoria. It has been introduced into India; and *Eucalyptus globulus* has been introduced into India, South and North Africa, southern Europe, Florida, and California. Tasmania apparently produces the best timber.

Blue gum is hardy and quick-growing in districts generally free from frost. It attains its best development in the southern portions of Tasmania, where the heaviest cut is made close to good tide-water harbours. That grown on the hillsides is more highly esteemed than that flourishing in the low country. In the natural forests of Tasmania it is a remarkably sound, clean timber. Logs often run 60 ft. from the butt without a knot. In the artificial plantations of California the tree is tall, straight, and exhibits a good piling form, but is full of dead knots. The Tasmanian and Victorian timber is far older than that cut elsewhere. In its natural habitat 60 years is the least age at which the timber is utilised. Most of the California blue gum has not attained this age.

Under ordinary circumstances the wood is hard, heavy, moderately strong, tough, elastic, curled and twisted in grain. In Tasmania it is fairly durable. According to trade reports from the latter country, the Victorian variety averages 5 lb. per cubic foot less in weight than the Tasmanian. In durability the mainland timber seems to fall far below that grown in the island, since at Melbourne blue gum from Gippsland is used only above the water line in wharves, although the marine wood-borers are practically absent. The young timber from California is not durable, rotting rapidly in contact with the soil. All blue gum is alike in its tendency towards excessive chocking. This is guarded against in Tasmania by banding the ends of the logs. In the younger growth of California it is almost impossible to prevent the opening of wide and deep chocks. Sawing off the split portion is no remedy, since the material again splits from the new cross-section.

Stringybark is a smaller tree than blue gum. It is generally distributed in Tasmania. Probably the finest stands are in the north-western and south-eastern portions, in the coastal and semi-coastal situations. Gigantic trees are found there. The wood is lighter in weight and softer than blue gum, the grain straight, even and rather coarse. It is strong, tough, splitting freely, and liable to shakes and gum veins. It is apparently more durable than blue gum.

From blue gum especially enormous piles are cut, 100 to 120 ft. long, 20 in. sq., and showing very little taper. To get a pile 100 ft. long a tree must run 150 ft. to the first branch, and from 15 to 18 ft. in circumference 5 ft. from the ground. The Tasmanian lumbermen claim that, if desired, piles 160 ft. long can be cut. Piles from Californian-grown timbers a few years ago averaged 30 to 35 ft. long, and from 12 to 24 in. in diameter.

All Tasmanian piles are hewed square. According to K. C. Richardson*, who went to the island to obtain piles for the Dover (England) harbour works, it is of the utmost importance that all hewn piles having the heart boxed in the centre should be prepared from matured trees. Saplings grown on moist and rich soil are unserviceable for that purpose. This eliminates the hewing of piles from California blue gum. In the latter region the piles are set round. Nothing definite regarding the condition of seasoning necessary has been determined. Some users discriminate in favour of piles from the older slow-grown trees cut in winter and thoroughly seasoned; others favour piles driven green immediately after cutting. Perhaps with the younger quickly-grown trees, immediate driving serves to prevent excessive chocking, while with the older, slow-grown timber seasoning serves to fix the kino-tannic acid content which is believed to be the resistant property of the wood. Probably the older, slow-grown timber is harder and thus more effectively resists the limnoria.

In some cases the heaviness of blue gum and stringybark is in their favour for pile purposes. At Dover, England, the strong current made it necessary to weight the tips of the Douglas fir piles used so that they would stand vertical before driving in 47 ft. of water. With blue gum the weighting was not necessary, thereby insuring a saving of 50 dols. per pile.† The weight is, however, often disadvantageous, since the piles cannot be floated but must be handled from lighters.

Because of its great elasticity Tasmanian blue gum is able to withstand the blows of the heaviest hammer without crushing or splitting. It is often necessary to place a cushion on the head of the pile to prevent undue rebounding of the hammer. Stringybark is not so dense or heavy, and is more liable to split in driving.

It is undoubtedly possible to substitute for blue gum, since in Victoria several inferior species have a similar appearance. The Tasmanian and Victorian Governments inspect all timber for 3*d.* per 100 superficial feet of hewed piles. The Tasmanian brands are shown:—

1 T	2 T	3 T	4 T
TAS	TAS	TAS	TAS
B G	S B	P	I B
Blue Gum	Stringybark.	Peppermint.	Ironbark.

The initial figure represents the number of the inspector doing the work.

Under present conditions the price of California blue gum runs considerably higher than that of Douglas fir and redwood. A few years ago piles 30 to 35 ft. long, 12 to 24 in. in diameter, cost 17 to 43 cents per lineal foot.

In Tasmania the shipworm does not seem to

* "The Jarrah Timber of Western Australia." Prof. Papers, Corps of Royal Engineers, vol. xiii, 1864.

* "Notes re Timbers of Western Australia."

† "Destruction of Timber on the South African Coast by Marine Wood-Borers." Proc. Cape Society C.E., vol. ii, 1905.

* "Eucalypti Hardwood Timbers of Tasmania," Gray Bros., Hobart.

† "The Tasmanian Blue Gum—An Ideal Timber for Harbour-Building," by H. J. Shepstone, *Scientific American*, January 21, 1905.

commit severe ravages, whereas the limnoria is quite active. A hardwood resists the limnoria far better than it does the shipworm. All piles used in the extension of the Hobart wharves are of stringybark, which is there considered more resistant to the shipworm than blue gum.

Barr* reported that blue gum was used in the construction of the staging for a mole at Otago harbour, New Zealand. At Auckland, N.Z., blue gum piles had to be protected to give satisfaction.

At Dover pulling and redriving several times tended to preserve the piles by killing any borers that had already secured lodgment.

Both blue gum and stringybark have been tried by the Netherlands Government, but at present Demerara greenheart is preferred.

Some blue gum was imported from Tasmania for the Admiralty Works at Simon's Town, South Africa, but most of the timber used was grown in the Union. The acting chief engineer of the Durban Harbour Board (1907) reported that the blue gum grown in the Colony was not nearly so good as imported jarrah and turpentine.

At San Diego, Cal., the blue gum grown in the state has not shown itself to be very resistant to limnoria.

Totara (*Podocarpus totara*) is also known as "New Zealand yew"; it grows in New Zealand. Its wood resembles pencil cedar. It is moderately hard, straight, and fine-grained, but does not warp or twist. The heartwood is very durable; its seasoned weight varies between 28 and 37 lb. per cubic foot. In 1876 newly fallen timber weighed as follows: Hokianga totara, 60 to 62 lb. per cubic foot; Wangarei totara, 60 63 lb.; and Pulhoi totara, 66 to 68 lb. per cubic foot. That from the higher hills and the country north of Auckland is considered best, but recently in calling for tenders for special heart of totara, the engineer of the Auckland Harbour Board received but one offer, and that for timber from the south.

Totara is expensive and increasingly difficult to obtain in large sizes. Large logs yielding a great deal of desirable heart timber are very brittle, and crack and splinter under the impact of vessels falling alongside.

According to Kirk,† totara piling should be driven green, and, where possible, with the sapwood removed. The Auckland Harbour Board specifies heartwood, reasonably straight, rough-hewn, to square 16 in. at the top and 10 to 12 in. at the toe. The piles are driven top downward.

The cost, according to Barr (1892), at the landing place was 3*s.* 5½*d.* to 3*s.* 10*d.* per cub. ft.; the material being 18 to 21 in. in diameter. Even then it was cheaper than jarrah.

In 1876 the engineer of the Auckland Harbour Board recommended that in the future piles should be procured as large as possible, say 15 to 17 in. sq., trimmed free of sap, and that only the heaviest timber from full-grown trees should be used. In 1880 the Government replaced all the jarrah piles in the Mangere bridge with totara. Barr reported that the latest wharves at Dunedin were built of totara.

No other untreated timber lasts so long as totara in Auckland harbour. The crustacean borers (like the sphareoma) eat away the ends of the walings and bracings, especially around the bolt holes. This, however, will happen with any timber, treated or untreated, when the ends are exposed to the severe depredations of crustaceans like the limnoria, cheluria and sphareoma in any port. The remedy is to discard braces and use raking piles.

Totara is still in use at Auckland, but almost entirely for the fender and rubbing pieces of concrete piles, of which the wharves are now largely composed.

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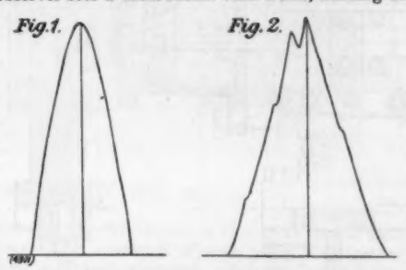
46. Correspondence: American Consul-General, Tientsin, China, April, 1912.
47. Correspondence: American Consul, Melbourne, Australia, 1912.
48. Correspondence: American Consul, Hobart, Tasmania, April, 1912.
49. Correspondence: Engineer, Wellington Harbour Board (New Zealand), 1912.
50. Correspondence: Eng. Auckland (N.Z.) Harbour Board, 1912.

* Proc. Inst. C.E. of Great Britain, 1892.

† "Forest Flora of New Zealand," Wellington, 1889.

HOMOGENEITY OF VISIBLE RADIATIONS.

What is known as homogeneous radiation, *i.e.*, radiation of one specified wave-length, in X-ray work, corresponds to what is called monochromatic light in spectroscopic examination. The latter term—if not the former as well—is convenient, but purely ideal. For no matter how narrow the slit of the spectroscope, any spectrum line photographed will have a definite width and consist of an indefinite number of images of the slit, side by side, formed by rays of different wave-lengths. The observer sees a band rather than a line, shading off



on both sides; the central, intense portion of the band will mark the natural vibration or "note" of the vibrating atom, the intensity becoming zero on both the sides, where the light is not sufficiently strong to affect the plate. The broadening of spectrum lines has been explained by Lord Rayleigh. When the discharge is sent through a gas and a condenser is inserted into the circuit, however, the broadening becomes anomalous, and that has not yet been explained. There are two other effects. A strong magnetic field splits up a line of a spectrum into several components; that is the Zeeman effect, which has long been fairly well understood. J. Stark—and also A. Lo Surdo—quite recently observed, however, that strong electric fields of thousands of volts per centimetre also split up the lines in a different manner,* and an explanation for this Stark effect has not yet been found. It is with the condenser discharge and the Stark effect that Professor J. W. Nicholson, D.Sc., of King's College, London, dealt in a discourse delivered to the Röntgen Society and published in the October issue of the journal of that society.

We have to go back to the general, or normal, broadening of any spectrum line and the natural "note" of the vibration. That note, Professor Nicholson pointed out (following Lord Rayleigh), will be changed on the Doppler principle when the vibrating atom as a whole is moving, just as the note of the engine whistle appears to change when a train is rushing past an observer. When the electric discharge passes through a tube, bodily motions of diverse magnitudes will be going on in the vibrating atoms, and the frequency of the vibrations in the line of sight will be changed; these considerations have led to a knowledge of the relative masses of the atoms emitting the lines which would be monochromatic in the absence of bodily movements of the atoms. When, now, a condenser of variable capacity is introduced, the broadening is very much increased in an anomalous way, and the shading off is in some cases no longer symmetrical. When Stark succeeded in splitting up lines of hydrogen by electric fields—for instance, the Hγ line which is itself separable into 27 lines, the distance between which increased as the electric field was made more intense—he suggested that this new (Stark) effect was at the root of the anomalous broadening of the lines under condenser discharge; his lines, he thought, would with a condenser discharge be sufficiently broad—perhaps by virtue of atomic velocity—to overlap and to form a wide band. Together with Dr. T. R. Merton, Professor Nicholson has tested this suggestion in a novel and interesting manner.

Their apparatus comprises the ordinary spectroscopic equipment (a Hilger deviating spectroscope or a concave grating, 20,000 lines to the inch) and an accessory, a neutral-tint wedge of the kind used for recording the sensibility curves of photographic plates. Such a wedge, so cemented to a wedge of clear glass that the combination forms a plane-parallel plate, is mounted vertically immediately in front of the slit, which has a width of 0.025 mm. The absorption by the wedge is not selective, and the wedge is so arranged that the slit is parallel to the direction of maximum increase of wedge thickness. The lower part of any spectrum line then passes through the thin end of the wedge and is little weakened, whilst the upper part of a line is more attenuated and the length of a line therefore shortened; the upper end of a line will mark the point where the light is just sufficiently intense to affect the photographic plate. Hence the most intense wave-lengths will give the longest lines, the weak wave-lengths will give short lines. When a curve was traced through the top ends of the images, Dr. Nicholson explained, measurements could be made on the plate, and, the law of absorption being known, the law of the distribution of intensity across the band be calculated. As it was very difficult, however, to determine where a faint line ended, the photographs were not taken in the ordinary way, but through a process screen, ruled with two systems of lines at right angles to one another, 100 lines to the inch. The lines then appeared resolved into series of small dots, extremely close to one another, and instead of picking out the extreme boundary of visibility, the experimenter picked out the last black dot in any direction. In that way they had practically eliminated the personal equation in drawing the intensity curves, and the results thus obtained were much more concordant and in agreement with theory than those obtained by tracing the curve on ordinary photographs. Further particulars of the method were given by Drs. Nicholson and Merton in the Transactions of the Philosophical Society, June 28, 1916, page 547.

Fig. 1, annexed, illustrates one of the curves obtained, and it is nearly parabolic. If the lines were merely broadened by atomic velocities, after

* Compare Sir J. J. Thomson's lecture, Engineering, vol. ci, page 380, April 21, 1916.

THE McMEANS AND BOSLER CUTTING-OFF MACHINES.

CONSTRUCTED BY THE SOUTHWARK FOUNDRY AND MACHINE COMPANY, PHILADELPHIA, PA., U.S.A.

(*For Description, see opposite Page.*)

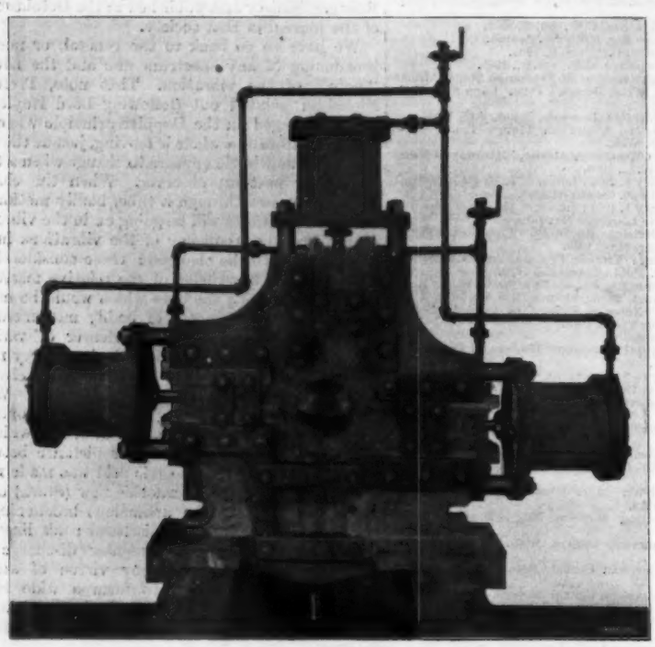
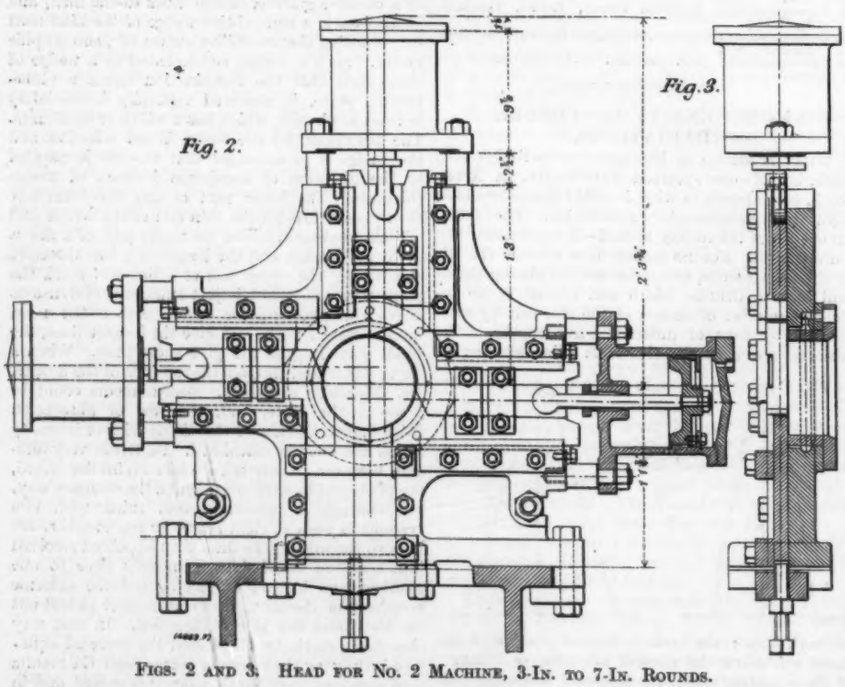
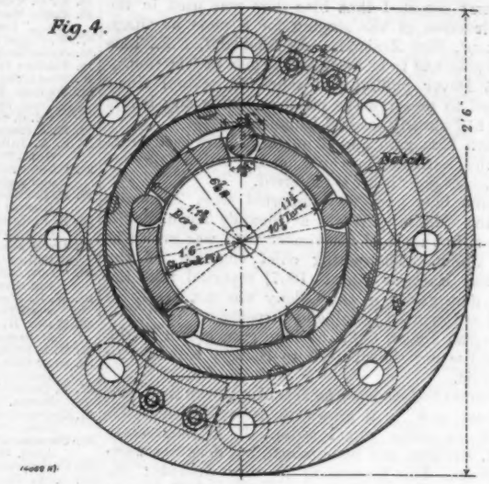
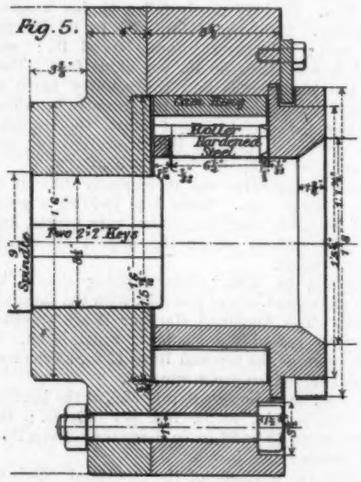


FIG. 1. CUTTING-OFF HEAD FOR 3-IN. TO 7-IN. ROUNDS.



FIGS. 2 AND 3. HEAD FOR NO. 2 MACHINE, 3-IN. TO 7-IN. ROUNDS.





FIGS. 4 AND 5. CHUCK FOR 10¼-IN. ROUND.

Rayleigh's theory, the curve should be a parabola of smooth, regular curvature. If, however, the law of intensity distribution was a simple exponential law, not in accordance with kinetic theory distribution of atomic velocities, every individual component should give a definite peak, and if the lines overlapped, as Stark assumed, a composite curve would result, showing more or less rounded peaks at spots where any component had maximum intensity; Fig. 2 illustrates such a curve of a helium line (already double in the ordinary discharge) obtained with a condenser discharge; that the number of kinks on the two sides was not the same was probably due to the fact that the line was not simple to start with. These photographs supported Stark's suggestion, quantitatively and qualitatively. The ratios of the horizontal distances between the kinks were really the ratios of the distances between Stark's components. Thus in a condensed discharge the splitting up of the lines was the same as that which occurred with a field of, say, 30,000 volts per centimetre—Stark has gone up to much higher volts —applied directly to the tube. Each of these lines was broad enough to overlap its neighbour, but this broadening was not of the same kind as the broadening with an ordinary discharge. The nature of the curves [it will be seen that the curvatures are of the opposite sense in Figs. 1 and 2] showed that the intensity distribution followed a simple exponential law and could not be explained on Doppler's principle by atomic velocities. There were thus two phenomena, different wave-lengths and a curious broadening, the Stark effect. The lines broadened more and more, quite apart from intensity, as they receded from the central line of the ordinary discharge. What the Stark effect meant in connection with radiation is not yet understood. Dr. Nicholson did not suggest any explanation. Stark assumed that the broadening was due to the electric field of neighbouring particles. The atoms, Dr. Nicholson thought, might get closer together in their disturbance by the condensed discharge, even to the extent of interpenetration. An electron actually passing through an atom could easily produce, as calculatjon proved, a local voltage of the necessary magnitude. The atoms were, in fact made to do the work themselves, instead of this work being applied outside the whole assemblage.

In any case the condensed discharge affords new means of studying the complex spectroscopic phenomena. Two years ago King and Koch described, in the *Astrophysical Journal*, another

THE McMEANS AND BOSLER CUTTING-OFF MACHINES.

CONSTRUCTED BY THE SOUTHWARK FOUNDRY AND MACHINE COMPANY, PHILADELPHIA, PA., U.S.A.

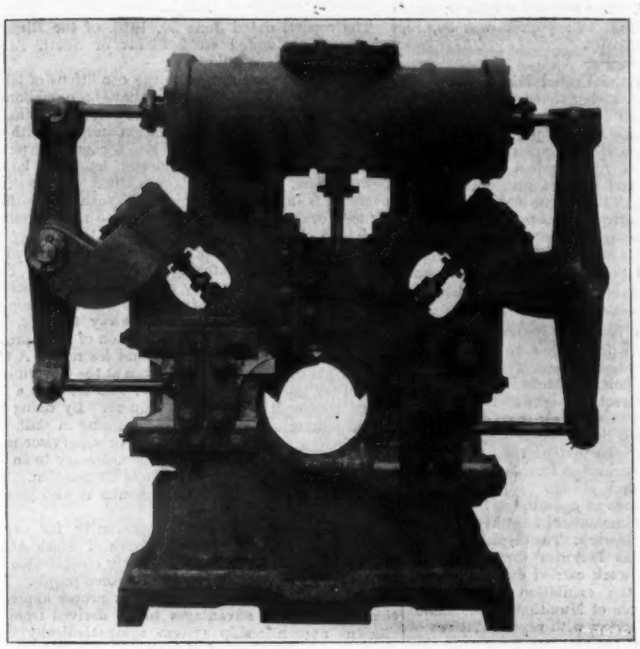


FIG. 6. CUTTING-OFF HEAD FOR ROUNDS 7 IN. TO 10 IN. DIAMETER.

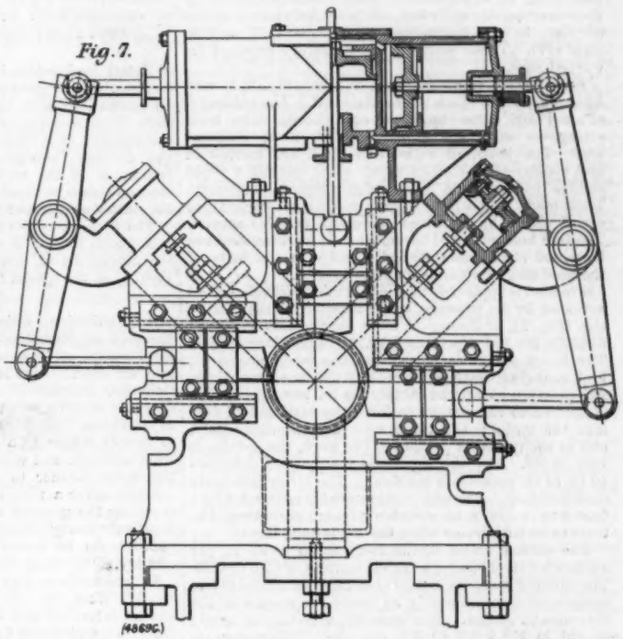


FIG. 7. HEAD FOR NO. 3 CUTTING-OFF MACHINE FOR 7-IN. TO 10-IN. ROUNDS.

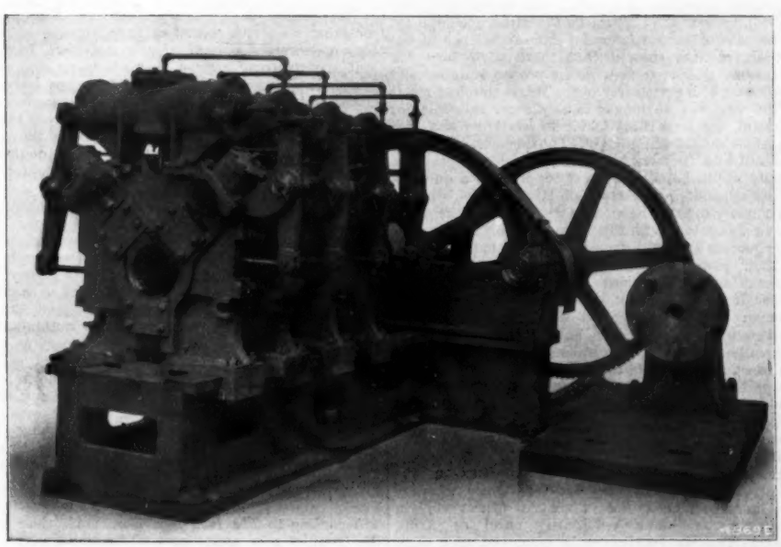


FIG. 8. FOUR-HEAD CUTTING-OFF MACHINE FOR 10-IN. ROUNDS.

method of studying the structure of the spectrum lines. They caused the photographic plate to move slowly in front of the slit while continuously recording any change in the intensity of the radiation by the aid of a photo-electric cell. The method of Merton and Nicholson appears simpler, though it also requires that all parts of a slit remain uniformly illuminated. Spectroscopic phenomena seem to become more complicated the more they are studied; but these observations seem to show a way out of the difficulties. That applies also to homogeneous X-rays, a point to which Dr. G. W. C. Kaye drew attention during the discussion of Dr. Nicholson's discourse. When Barkla announced the discovery of characteristic homogeneous X-rays, each element seemed to have one characteristic wave-length; later on the K and the L series were distinguished. There may be 10 or more lines in each series, as the studies of crystals prove, and further series have been suggested. Nobody has probably yet experimented with really homogeneous radiations, and that fact might suffice to explain the different character of the Röntgen rays emitted by a bulb when excited under different current conditions. The homogeneity of emission depends very much on circumstances.

CUTTING-OFF MACHINES.

THE recent demand for large quantities of short lengths of round bars has led to the development of a machine patented by Messrs. McMeans and Bosler, with manufacturing rights controlled by the Southwark Foundry and Machine Company, of Philadelphia, Pa., U.S.A., which differs radically from the usual type for cold cutting. The bars are cut direct from the mill and do not ordinarily require any straightening.

The machine is illustrated on the opposite and present pages, and on page 484. The tools, instead of being fed into the stock by a positive mechanical train, are controlled by air pressure acting through suitable cylinders with pistons and rods. The air, while forcing the tool into the stock so as to obtain maximum cutting, also provides a flexibility which prevents breakage should the stock turn eccentrically. There is an additional advantage gained in having three tools acting in a common kerf, each so fashioned that it does an equal portion of the work.

The machines are built in three sizes, any of which may be provided with one or more cutting heads, dependent upon the capacity desired. The usual maximum number is six, though machines have been built with eight heads. The sizes of bars accommodated by the three sizes are as follow:—3 in. to 7 in. (Figs. 1 and 2, page 476), 7 in. to 10 in. (Figs. 6 to 8, annexed), and 10 in. to 15 in. One size of bar is usually provided for in each pattern of machine, though other sizes within the capacity of the machine can be cut by making slight changes.

Each machine consists of a substantial cast-iron bed, on which is mounted the gear train for driving the main spindle, this being of the hollow type. A quick-closing powerful chuck of the spiral roller type (Figs. 4 and 5, page 476) is attached to the spindle for driving the stock. It consists of a coupling forced on the spindle and keyed thereto. A cam retaining ring is through-bolted to the coupling and is shrunk on to the cam ring. The cam ring is of steel accurately machined and hardened. (For the smaller sizes the cam retaining ring and cam ring are combined.) Hardened steel rollers held in position by a retaining ring act against the inclined faces of the cam ring. The retaining ring has a rotary movement with respect to the cam ring and also serves to centre the stock. When the stock is inserted in the chuck and the spindle rotated, the rollers are retarded and moved inward by the cam ring, thereby firmly gripping the stock. In order to release the chuck it is only necessary to move the retainer forward, thereby carrying the rollers to a position on the cam ring which will permit them to move outward, releasing the bar. For the largest size unit a reversible motor is used and release is effected by reversing the drive.

The heads, from one to six or more in number (Figs. 1 and 2, page 476, Figs. 6 and 7, and Fig. 8 annexed, and Figs. 9 and 10, page 484), serve in two capacities; first, as a steady rest for the stock and, secondly, as the cutting head. They consist of a substantial steel or iron body (dependent on the size) mounted on the bed

and secured thereto by clamps at each side (Figs. 2, 3 and 7). Lateral movement is permitted to prevent breakage owing to warped bars. At the bottom an adjustable rest of hardened steel is provided (Figs. 2 and 7). In addition to the fixed rest at the bottom for the largest size, additional air-cushioned rests, consisting of a hardened steel guide actuated by double-acting air cylinders, are provided at an angle of 45 deg. to the horizontal (see Figs. 6, 7 and 8, page 477). These provide the flexibility required for warped bars.

A renewable, hardened steel bushing (Fig. 3) is used where the bar of stock passes the head. The cutting is effected by three tools on each head, these tools acting, as we have already stated, in a common kerf. The tools, of high-speed steel, are carried in tool holders of the strap type, which permit a rapid change to be made when re-grinding is necessary. Tools made with a piece of high-speed steel welded into a soft shank have proved successful for this service. The tool holders are of hardened steel working between hardened steel liners carried directly in the body of the head and are retained in place by gibs.

Pressure is applied to the cutting tools through pistons actuated by air pressure, either directly for the smaller size (Fig. 2), or through a lever for the side tools and directly for the top tools (Fig. 7) in the larger sizes. The latter arrangement permits the ready access for tool changing which is desirable in the larger machines. Air pressure at approximately 70 lb. per square inch is applied to the pistons to force the cutting tool feed into the metal; the three tools act simultaneously, and as each does its portion of the work, the cutting is very rapid. For the auxiliary steady rest cylinders 40 lb. of air pressure is required. The air cylinders are double-acting. The piston movement is controlled by a four-way valve with suitable piping, permitting the tools to be withdrawn when the cut is completed.

The surface speed of the stock is 35 to 40 ft. per minute for steel having a carbon content of 0.45 to 0.55. The cutting time for a machine may be expressed in seconds as approximately $3\frac{1}{2}$ times the square of the diameter in inches. For example, a 10-in. bar would be cut in $10^2 \times 3.5$ or 350 seconds. This represents the actual time to cut to approximately one-third the diameter of the bar, or at a point where it may be readily broken. The time for cutting through would be in excess of this. The first method seems preferable, as it not only increases the capacity of the machine, but gives a ready examination of the fractured stock.

As the cutting is rapid and production large, the power required is in proportion. For six-head machines the following sizes of motor (or other prime mover) are required:—

Capacity of Machine.	H.P. (Motor).	Speed.
5 in. to 7 in.	75	500–700 R.P.M.
7 in. to 10 in.	100	,, ,,
10 in. to 14 in.	150	,, ,,

As the capacity of the machine is dependent upon the time required to handle the stock in and out of the machine, a roller table with air-operated pusher cylinders is recommended, this being arranged as shown in Fig. 9, page 484. It consists of a structural steel bed carrying the rollers. This is placed at the tail of the machine. The stock is placed on the table and pushed through the heads to the chuck by the air cylinder. When the cutting is completed an air cylinder whose piston rod passes through the hollow main spindle serves to eject the bars.

A six-head machine of the type described above has cut, in 12 hours, a pile of $5\frac{1}{4}$ in. rounds measuring 45 ft. in length and 9 ft. in height. On the same machine over 4,000 $5\frac{1}{4}$-in. slugs have been cut in 23 hours.

INDUSTRIAL NOTES.

The Director of the Department of Labour Statistics, writing in *The Board of Trade Labour Gazette*, on the state of the labour market, says that during October more men were enlisted in the forces, with the result that the shortage of labour became more acute; and as this removal of men from industry must continue, it is necessary to adopt every possible expedient to economise man-power, so as to maintain the industries which are of national importance at the present time.

The changes reported as taking effect in October affected about 290,000 workpeople, and resulted in a total increase of nearly 36,000*l.* per week. The largest bodies of workpeople affected, in addition to engineers at various centres, were coal miners in Northumberland, woollen and worsted operatives in the Huddersfield district, workpeople in the printing and bookbinding trades in London, and iron puddlers and millmen in all the principal districts.

The number of disputes beginning in October was 40, and the total number of workpeople involved in all disputes in progress was 18,697, as compared with 11,959 in September, 1916, and 20,502 in October, 1915. The estimated number of working days lost by disputes during the month was 106,600, as compared with 180,300 in September, 1916, and 156,700 in October, 1915.

The average weekly number of vacancies notified to all Employment Exchanges for the five weeks ended October 13 was 40,005, as compared with 38,717 in the previous four weeks and with 34,838 in the five weeks ended October 15, 1915. The average weekly number of vacancies filled for the same periods was 30,413, 31,156 and 25,398 respectively.

Retail food prices in the United Kingdom on the 1st inst. were 5 per cent. higher than a month earlier. In comparison with those of November 1, 1915, they showed an average increase of 27 per cent. Taking the country as a whole, and the figures for food only, the average increase in retail prices between the beginning of the war and the 1st inst. was 78 per cent., which is reduced to 72 per cent. if the increase in the duties on tea and sugar is deducted.

The Director of the Department of Labour Statistics was unable to publish this month particulars regarding the movement of retail prices of food in Berlin and Vienna, as the official figures had not been received.

An exhibition, which has been promoted by the Ministry of Munitions, with a view to making the employment of women on munition work still more popular than it is, is being held in the McLellan Galleries, Sauchiehall Street, Glasgow. It is hoped that the excellent exhibits of work done by women in munitions factories will induce employers to resort to female labour to a greater extent than they have done hitherto, and will encourage foremen and skilled tradesmen further to train women operatives. The exhibits cover a wide range of operations, from those requiring the greatest mathematical accuracy to comparatively heavy projectile work. The display contains photographs of munitions factories throughout the country, illustrating the work carried out by women.

In connection with the exhibition in question, Mr. W. Weir, the Director of Munitions in Scotland, had an interview last Monday with representatives of the Press, and stated that the real lesson for us in this country was that, whatever degree of success might have been achieved hitherto in the manufacture of munitions, the future must see an absolutely overwhelming increase. To enable this to be done, our main industrial asset would be the rapid development in the use of female labour. The experience of the last six months showed that there were very few operations which women, given proper training and assistance, could not carry out. While the final result of the war was no longer in any sense indefinite or doubtful, the important factor to everyone was that the Allies should win quickly. The duration of the war was still to a very large extent an industrial problem. Supply would be the test, and supply was a question of the efficient organisation of labour. The debt of our country towards its women workers was very great, and in connection with this it was incumbent upon the management of the different establishments to do all in their power to make the working conditions as pleasant and as efficient as possible. During the winter it was necessary that every works manager, foreman and under-foreman should carefully think out the different operations, and arrange to subdivide and simplify them so as to utilise female operatives for the work. There should also be loyal co-operation on the part of the skilled tradesmen. The direct result would be the giving to our armies that superiority in supply which, in conjunction with their fighting superiority, would hasten the victory we so much desired.

Arrangements have been made between the Ministry of Munitions and the War Office whereby men in certain categories of medical fitness may in certain circumstances voluntarily enrol as Army Reserve Munition Workers to be employed upon work in connection with the production of munitions of war. Full particulars of the Army Reserve Munition Workers Scheme can be obtained at any Employment Exchange. Men may be enrolled as Army Reserve Munition Workers under this scheme who belong to any of the three classes described below:—(1) Men referred back by the Tribunals to find work of national importance as the condition of their being exempted from military service. (2) Men who have been called up and relegated to the Army Reserve, or who on being called up would be relegated to the Army Reserve as not at present needed in the Army. (3) Men at present serving in units at home who are classified as B. 2, B. 3, C. 2, or C. 3, and who are surplus to the requirements of their unit for men of their category and medical fitness.

Men who are suitable and whose cases fall under heads (1) and (2) above can only volunteer under this scheme with the concurrence of the Local Tribunal or of the Local Military Authorities. The selection of men already serving with the colours who are willing to be transferred to the Reserve for munitions work will rest with the officers commanding their units. Men selected and found to be suitable for the purpose will be enrolled as Army Reserve Munition Workers by the Employment Exchanges. In no case should application be made in writing or in person to the Ministry of Munitions or the War Office.

The report, dated June 30, 1916, of the Directors of the Consolidated Gold Fields of South Africa, Limited, states the following:—

"During the last few years the conditions of labour on the mines of the Witwatersrand have been ameliorated on account of the attention bestowed on the elimination of dust, on underground ventilation and on health and safety measures generally, and also because of extended annual holiday leave and shorter hours of labour. Nevertheless, the supply of skilled miners from overseas is diminishing rapidly. Vacancies are filled by men drawn from South Africa who rank as miners and take charge of native workers, after undergoing a short and very imperfect apprenticeship which consists largely in watching natives at work. Such supervision is proving very costly and unsatisfactory, particularly as so much of it has to be used to replace in a measure the men who are away fighting, and there is great need for the introduction of an improved system of training for underground learners. A step in the right direction has been taken at the Government School for the training of miners, who undergo a two years' course in the work of mining. By doing the actual mining work the native is gaining in skill, and it is obvious that the white miner or supervisor must also make such progress as may be necessary to enable him to command respect and uphold his position. The apprentice system for mine mechanics is also greatly in need of revision.

"The deplorable lack of opportunity for expert training in trades of the white youth of South Africa is a very serious matter which greatly complicates the relative position of the white and coloured people. The subject should be approached with a proper appreciation of the great advantages to be derived from an efficient apprenticeship system sympathetically conducted with the view of reducing to a minimum the ranks of the unemployable and of inspiring respect and happy relationships between employer and employed."

The United States, says *American Machinist*, is receiving gold and securities from Europe in return for an enormous volume of raw materials, foodstuffs and manufactured articles that are being sent to the belligerent nations. Many industries are busy contributing to this stream of exports, but manufacturing conditions have not undergone any important change. Apart from some accumulation of skill in the manufacture of a few kinds of munitions, it is doubtful if the American industries possess anything to-day that they did not have on August 1, 1914.

By contrast, adds our contemporary, the machinery-building plants of Europe have learned much. They now understand thoroughly the principles and advantages of mass production; they know the results that flow from intense application in industry; they have had the stimulus that comes from a spirit of sacrifice; mechanical skill has been spread broadcast through classes of society that previously knew nothing about it; they have utilised automatic machinery as never before; they have developed and applied special-purpose machinery in a way hitherto unknown; and they have learned the advantage in production of using highly-developed small tools.

Our contemporary concludes by stating that European industry is gaining tremendously through the stress of war, the United States having no equivalent for this stimulus.

According to *The Iron Age*, New York, the root of the troubles now annoying the American iron trade is the scarcity of labour; the works at present need three men where two were ample before. It is not that the American industries are actually short of men, the scarcity of labour is due to the fact that the industrial expansion is proceeding at a greater rate than the increase in the labour supply.

"For this state of affairs," adds the American journal, "there appears to be no immediate remedy. Our supply of men such as we need cannot be quickly increased so long as European nations are drawing every available subject into their armies. It is a condition that will have to be borne philosophically. The employer who chooses to do so can, of course, win men from other employers by paying higher wages. But there is a limit to this, as eventually the cost of production cuts up all profits. We need to slacken our pace and lessen our efforts to grasp more and more of the business coming in sight, recognising that even prosperity may have its bounds."

At Leeds last Sunday Sir J. Compton Rickett, M.P., said he was glad to note that the war had

brought about a better social feeling and a stronger sense of comradeship between class and class, and between individuals. He thought that after the war two dangers would have to be guarded against, one being an export of labour and the other an export of capital. There would occur a certain amount of restlessness on the part of many men who returned to the common daily task, and if there was any friction at home the danger to the country would be that a certain amount of such labour would seek some other part of the world. It was also very desirable that the great textile trades should continue to have their centre here and carry on their operations from this country as of old—instead of works being set up abroad nearer the places of production and market—because our enormous mercantile marine largely depended upon our in-and-out trade. We had to import food, and we needed to export our manufactures so as to keep freights as low as possible. He was, he said, a profound convert to the doctrine of the minimum—or living—wage. In every great trade there should be a minimum wage fixed every six months, or based on the Board of Trade returns showing the cost of living, and it might be worked on an automatic scale. He would advocate the closing of a business if it could not pay its operatives a living wage. He would also advocate that both employers and employed should belong to respective unions. He knew from the testimony of many employers that they would rather have unions, such as existed at present, than have to deal with an indiscriminate mass of people. He would give these unions a statutory position, and would have both employers and employed governed by the majority, the minority not having the right to break away. The great unions of the present days gave the indication of a want of cohesion, and this was a danger. There should be arbitration courts for the division of profits between labour and capital, and no strikes should be lawful until the case had been arbitrated upon, and an agreement found impossible. There should also be some regulation of competition, and the State should be able to direct both capital and labour into the most profitable channels.

We are informed that a conference, called a "rank and file conference," which had been promoted by the Metal, Engineering & Shipbuilding Amalgamation Committee, took place last week at Leeds, when the following resolution was put and carried :—

"That realising, as at present organised, the trade union movement is entirely inadequate, this conference of the rank and file demands that the executives of all unions (catering for engineering and shipbuilding workers) immediately get together and formulate a practicable scheme of amalgamation that shall fuse all sectional unions into one industrial union, having as its object the organisation of all workers in the industry, regardless of craft or sex ; and, as its ultimate aim, the control of industry for the complete abolition of the wages system."

An amendment to delete the words "regardless of craft or sex" was defeated by a large majority.

The conference expressed the opinion that action should be taken on the initiative of the Amalgamated Society of Engineers within three months.

The conference was the outcome of one held in London last August, at which a resolution was passed calling upon the executive committees of all unions of engineering workers to fuse all the sectional organisations into one industrial union, comprising every worker in the industry, regardless of craft, grade or sex, the aim being to obtain complete control of the industry.

Mining Machinery.—This is a period of general contraction in our exports, but it is satisfactory to note that mining machinery has been an exception to the rule, the shipments for September having been 2,218 tons, as compared with 1,368 tons in September, 1915, and 1,989 tons in September, 1914. The increase observable was accounted for by a larger demand upon South African account, the deliveries to that quarter in September having been 1,407 tons, as compared with 684 tons and 699 tons. The aggregate exports of mining machinery to September 30 this year were 15,114 tons, as compared with 12,958 tons and 17,115 tons in the corresponding periods of 1915 and 1914. Shipments to South America to September 30 amounted to 340 tons, as compared with 286 tons and 1,014 tons. The colonial demand during the first nine months of the last three years is indicated by the following exports :—

Colonial Group.	1916. Tons	1915. Tons	1914. Tons
South Africa	7,863	6,356	6,278
British India	1,519	813	1,507
Australasia	657	831	1,199

The increased demand upon South African account is attributable to the start which has been made upon an extensive scale in developing the mineral resources of the Eastern Transvaal. The value of the mining machinery exported to September 30 was 528,934*l.*, as compared with 444,653*l.* and 646,361*l.* in the corresponding periods of 1915 and 1914 respectively.

RELATIVITY AND OTHER NONSENSE.

To the Editor of Engineering.

Sir,—As the writer of the first letter on this subject, which appeared on page 178 of Engineering, August 25, I beg to point out that, though "The correspondence on Relativity has been somewhat ironical, not explanative," very little light is thrown upon the matter (or upon quanta, electrons, gravitation and tensile strength) by the three correspondents in your issues of October 20 and 27.

No dependence can be placed on Bergson ; and everyone interested in this branch of philosophy should read Hugh Elliot's "Modern Science and the Illusions of Professor Bergson" (Longman's, 1912), in the Introduction to which Sir E. Ray Lankester wrote :—"To the student of the aberrations and monstrosities of the mind of man, M. Bergson's works will always be documents of value."

Your excellent article to-day, "Science and Engineering," is most helpful ; but, as illustrating that need of precision to which I venture again to call attention, let me ask what do we mean by "Science" ? Huxley suggested *organised knowledge*—which generally "fills the bill" ; but, as you say, Sir, "Engineering is not now, and presumably never will be, one of the exact sciences," from which it is clear that Huxley's term cannot be used in the plural !

Heuristic methods are good in their way ; and, when he has *discovered* something, a chemist drops his "h" and cries "Eureka" ; but an engineer must be able to invent, to devise means of *doing things* ; so that, while philosophers and mathematicians may be quite right in their view that squaring the circle is impossible, a task which no one except a paradoxer or perpetual-motion crank would attempt, as the exact value of π is unknown and can never be determined, the engineer, knowing π to 125 places of decimals, finds $\sqrt{\pi r^2}$ quite near enough for all practical purposes ; and he takes 3.5448 in. as the side of a square equal in area to a 4-in. circle (12.5664), which I have purposely chosen because its area and circumference are numerically the same—an exercise in Relativity.

November 10, 1916. "Sesamy."

"SPARK IGNITION."

To the Editor of Engineering.

Sir,—With reference to the article on "Spark Ignition," published in your issue of the 3rd inst., laboratory research does not always agree with actual working conditions.

The following figures relate to tests taken on a 25-horse-power four-cylinder engine, and were given in a paper read before the American Society of Automobile Engineers about twelve months ago :—

Revolutions per Minute.	Horse-Power.		Petrol Consumption in Pounds per Horse-Power Hour.	
	Magneto.	Battery.	Magneto.	Battery.
400	5.5	5.5	1.41	1.40
600	9.6	9.7	1.10	1.08
800	14.0	14.0	0.89	0.93
1,000	18.7	18.0	0.77	0.80
1,200	20.7	19.8	0.80	0.85
1,400	22.7	21.0	0.85	0.94
1,600	24.6	22.8	0.82	0.91
1,800	23.8	22.5	0.85	0.97
2,000	22.0	18.9	0.97	1.11

The timing in the case of the magneto was fixed, the battery ignition being regulated to suit the speed, this obviously was not to the advantage of the magneto.

The figures are eloquent and require no embellishment.

Yours faithfully,

Acton, W. Wm. L. Gullette.

SCIENCE DEGREES.

To the Editor of Engineering.

Sir,—To secure the fullest possible application of science to industrial problems it is of greater importance that the staff of each works should include men of sound scientific training than that external bodies of scientific experts should be ready to assist industry by solving problems sent to them. It is a pity, therefore, that for the practical man earning his living there is so little encouragement to systematic scientific study. However proficient in science he may make himself, he cannot expect the recognition that is accorded to the man who can write "B.Sc." after his name. His book, if he writes, is rejected by the publishers in preference for the book of the college-trained B.Sc.—much to the loss of our technical literature. Why, then, become a scientific expert ?

If the practical man wishes to take his B.Sc. degree he must pass the London Matriculation examination, involving a knowledge of a language, English history, English literature, &c., and these constitute a pretty formidable preliminary for the man with limited time, anxious mainly to study the structure and laws of the universe in which he has to live and work. Moreover, while I keenly appreciate the high standard of general education required by our universities and am strongly in favour of retaining the B.Sc. degree on its present basis as the science degree of the educated gentleman, it is nevertheless true that for purposes of commerce and industry—to meet effectively German competition after the war, for example—the practical scientific expert need not know the present participle active of the Latin verb *fingere*, nor even the date of the death of Queen Anne.

I suggest, therefore, that some authoritative body should arrange to hold examinations and confer marks of distinction on candidates able to prove their proficiency in science—marks of distinction that shall mean that their possessors are at least equal to the average B.Sc. in matters scientific, though not in general education. In order that the distinction may be valuable, and therefore attractive, the standard of proficiency required must be high, but all other deterrents should be avoided as far as possible. Examination fees should not be abnormally high, and there should be no annual subscription to be paid afterwards. No qualifications for candidature should be required other than scientific proficiency, except perhaps—and I rather hesitate to suggest even this—that the candidate should be able to write passably clear and grammatical English. The object to be kept in view should be to encourage the largest possible number of students to work for the distinction, so as to provide English industry with the largest possible number of capable, highly trained scientists.

Yours truly,

W. W. Padfield.

42, Lower Oldfield Park, Bath, November 2, 1916.

THE ROYAL METEOROLOGICAL SOCIETY.

The first monthly meeting of this society for the present session was held on Wednesday, the 15th instant, at the society's rooms, 70, Victoria-street, Westminster, Major H. G. Lyons, D.Sc., F.R.S., president, in the chair.

Mr. C. E. P. Brooks, M.Sc., F.R.Met.Soc., read a paper entitled "*A Meteorologist in China*," in which he described the work of the late Captain L. H. Tamplin, who resided in Eastern China from 1902 to 1915, and took very full and accurate meteorological observations, chiefly at Chinkiang, but for a time at Wuhu, and finally at Amoy. These observations are made the basis of a discussion of the climate of the coastal region of China and its controlling factors. In addition to his actual observations, Captain Tamplin's close acquaintance with the Chinese enabled him to note some quaint weather superstitions, and he also made some important observations on the causes of flood and famine in China.

A paper by Lieutenant A. E. M. Geddes, R.E., entitled "*The Storm of the 11th–13th November, 1915, in its Passage over the British Isles*," was also brought forward by Mr. R. G. K. Lempfert, M.A. This storm was remarkable for its close resemblance to a very severe storm which crossed the British Isles on November 11–13 in 1901. Both disturbances gave unusually heavy rainfall over Ireland and England, but in both cases there was very little precipitation over Scotland. All records available at the Meteorological Office have been examined, and from them weather maps have been constructed for intervals of two hours. From these maps the path of the centre of the storm has been traced with great detail. In this case the path skirted the southern coast of the British Isles, whereas in the case of 1901 it was from Galway to the Wash. The two-hourly maps have been used for working out the air circulation in the storm. Two distinct air supplies can be identified : (1) A supply of warm air from the south, and (2) a supply of much colder air from the east.

Metallic Permanent Way.—The exports of chairs and metallic sleepers have almost collapsed this year in consequence of the war, having amounted to only 162 tons in October, as compared with 2,693 tons in October, 1915, and 5,307 tons in October, 1914.

Our Locomotive Exports.—The exports of locomotives from the United Kingdom continue to decline, but they show, upon the whole, better results than might perhaps have been anticipated. The value of the engines shipped in October was 99,910*l.*, as compared with 148,901*l.* in October, 1915, and 368,540*l.* in October, 1914.

Examinations in Science and Technology.—(1) In the Prefatory Note to the volume of Regulations and Syllabuses for Examinations in Science and Technology, 1915, the Board of Education signified their intention to discontinue the Examinations at a date to be subsequently announced, and in Circular 921, dated August 31, 1915, they gave notice that after 1916 they would no longer hold Lower General Examinations in any subjects of Science and Technology, but that the Higher General Examinations would for the present be continued. Accordingly no Lower General Examinations will be held in 1917, but the Board hope to be able in that year to hold the Higher General Examinations, which would be conducted in accordance with the Regulations and Syllabuses which governed the conduct of those Examinations in 1915 and 1916. Should it, however, prove necessary at a later date to suspend the Examinations, the Board will endeavour to give as long notice of the change as possible. (2) After 1917 no Higher General Examinations will be held in Pure Mathematics, Theoretical Mechanics (Solids), Theoretical Mechanics (Fluids), Heat, Magnetism and Electricity, Organic Chemistry, Coal Mining and Metallurgy. (3) The conditions governing the award of Scholarships, Exhibitions, &c., in Science in 1917 are being announced separately. (4) The time tables of the Examinations to be held in 1917 will be issued in due course.

HIGH-PRESSURE AIR-COMPRESSORS.*

By Joseph M. Ford.

(*Concluded from page 472.*)

Testing Multi-Stage Compressors.

Although extremely interesting results can be obtained from scientific tests on air-compressors, the manufacturer is usually content with tests for the efficiency of the machine.

A purchaser requires to know the power required per cubic foot of air actually delivered, since this is the basis of comparison for compressors. The problem, then, is to determine exactly how much air is being delivered. The two methods usually adopted are: the "pumping-up" method and the orifice test. In the former the compressor is run at its full pressure, pumping into a reservoir, and from this latter the air is led to a receiver of known capacity. The details of the method are well known, being exactly the same in principle as used on tests of ordinary compressors for pneumatic tools.

The orifice test is now being largely adopted, on account of the possibilities of error with the "pumping-up" method due to inaccurate temperature readings, oil and water in the bottles, &c. The orifice test method is also well known in connection with ordinary compressor work and need not be described.

Useful information as to the condition of piston rings and valves may be obtained from indicator cards, which also show to some extent the efficiency of the cooling. If, on applying Brauer's construction to the diagram, the compression line is found to be almost isothermal, it does *not* necessarily indicate that the cooling is almost perfect, as is sometimes stated. The line may indeed *appear* to be the isothermal, due almost certainly to leaky piston rings or suction valves. Lines giving an exponent value in PV^n of less than 1.26 should be looked upon with suspicion.

If any stage pressure is very much above that estimated, the trouble will likely be due to the valves of the next higher stage leaking, or to its own delivery valve not being tight.

Judicious use of the cylinder drain cocks, and the behaviour of the stage pressure gauges immediately on shutting down, enable conclusions to be drawn as to the source of trouble, without the necessity of taking indicator cards.

Maintenance of Compressors.

The usual practices of engine maintenance apply to compressors, but unfortunately the care and attention given to these machines is frequently less than that necessary. Particularly is this the case in some Diesel engine plants, where the compressor, until it gives trouble, is looked upon as an engine detail.

The lubricating system, above all, must be kept in the highest state of efficiency, as failure in, say, the high-pressure stage, where there is usually considerable ring friction, generally leads to a cracked cylinder, which may not be the limit of the damage.

If the circulating water is chalky or muddy, the cooling system must be periodically cleaned if the highest efficiency is to be maintained. Valves should be examined from time to time for cracks. It is of the utmost importance that relief valves should be in perfect order, for these are in every way as important as a boiler safety valve, and under no conditions whatever should the valves be wedged or otherwise put out of operation to stop a leak. They should be tested for blowing off at frequent intervals. If stage pressures are rather higher than normal, it means probably, as previously explained, that valves are leaking.

Provided the pressures are not excessive no trouble will result from running in this condition, but matters should be put right at the first opportunity. In justice to Diesel engine air-compressors, it must be stated that the frequency with which the engine log book records "compressor trouble" is due in many cases to negligence.

There is still a big scope for improvement in the design of multi-stage compressors.

Modern Machines.

Through the courtesy of the various makers it has been possible to reproduce several photographs and drawings of some of the latest high-pressure air-compressors, and a glance at these will show at once the divergence which exists in design.

Fig. 30, on Plate XXXIX, shows a small three-stage compressor by Messrs. Peter Brotherhood, Limited, of Peterborough, the machine being chain-driven and having a capacity of 600 cubic feet of free air per hour, compressed to 3,000 lb. per square inch. As has been already explained, in small machines the tendency is to reduce the number of stages of compression for a given final pressure, and this statement is borne out by a comparison between this machine and that shown in Fig. 31. Although the working pressure of this latter is the same, viz., 3,000 lb. per square inch, the capacity is 10,000 cub. ft. free air per hour, or more than 16 times as great as that of the small machine, and in this case the compression is divided into five stages. The machine is steam-driven, two double-acting steam cylinders being at the ends and the air cylinders in the centre, and the air piston rods are coupled side by side to the horizontal bridle which is attached at its extremities to the steam line crossheads.

A complete set of indicator diagrams from this machine is given in Fig. 32. It may be mentioned that the shape of the suction lines in the cards from the fourth and fifth stages results from the fact that the cylinder volumes are fairly large compared with the cubical contents of the intercoolers, the lowest point on the line indicating the commencement of transfer. The comparatively small clearance volume in the first-stage cylinders, shown by the rapid drop in pressure on the back stroke, is also worthy of note, the reasons for the small volume having previously been discussed.

Fig. 33 (above) shows a four-stage direct-coupled machine by the same builders, capable of charging a 45 cub. ft. reservoir to 2,000 lb. per square inch in 80 minutes when running at 250 r.p.m., whilst the five-stage direct-coupled machine shown in Fig. 34 charges a 40 cub. ft. receiver to 3,000 lb. per square inch in one hour at 350 r.p.m.

A point to which attention may be directed is that the intercoolers on these machines are generally of the submerged type, that is, the cooler consists of a copper or steel pipe coiled round the cylinders in the tank. This tank construction simplifies very considerably the cylinder castings, and the cooling effect is probably enhanced due to the whole of the connections being submerged, but of course this method is not always admissible. The cooling is still further improved by water injection, the water in the case of a steam-driven machine being obtained by condensation, and therefore quite free from foreign matter.

The piston packing in these compressors is of the fibre-ring type, the high-pressure gland fibres being fitted in removable boxes, which can be repacked at the bench—an obvious advantage. All valves, which are mainly of the thimble type, have removable seatings, so that a replacement is readily effected.

An unusual feature of Messrs. Brotherhood's machines is the provision of an indicator to show that the circulating water is flowing through the casing, which in many cases is very convenient, as it is not always easy to arrange for the water to be discharged into a funnel. The importance of maintaining the circulation will be readily understood from a study of the temperature charts previously given.

Diesel Engine Compressors.—Special attention has been devoted by Messrs. Reavell and Co., Limited, of Ipswich, to the design of air-compressors for Diesel engines; their productions range from small hand-driven machines for charging starting bottles in case of emergency, to those used on some of the largest machines yet constructed.

A patented design of three-stage compressor by these makers, for 1,000 lb. per square in. working pressure, which has given very satisfactory results for marine work, is shown in Figs. 35 to 38, Plate XL, a special feature of this machine being the arrangement of the second or intermediate stage. By suitably proportioning the cylinder and intercooler dimensions it is possible to dispense entirely with valves in this stage, which means that the intercooler volume is part of the intermediate-pressure cylinder clearance.

The principle will perhaps be better understood by reference to Figs. 39 and 40, which shows the "Reavell" patent "V" class Duplex compressor. The air is delivered from the low-pressure stage down through the intercooler to the second stage cylinder, and on the down stroke it is compressed, and again passes up through the same intercooler on its way to the high-pressure cylinder—the high-pressure suction pipe being in direct connection with the low-pressure delivery passage. The only modification to the low-pressure valves which this entails is that the valve cover must be arranged to withstand the intermediate pressure delivery pressure instead of the low-pressure pressure as is usual.

Since the air passes through the same intercooler twice, only one of these is required instead of two, as with other designs, and apart from the simplicity of construction resulting therefrom, the efficiency is considerably increased owing to the fact that the second stage of compression is effected in the cylinder and cooler itself—the reasons for improved efficiency having already been dealt with.

The marine compressor under consideration is exactly the same in principle, only a single intercooler being provided.

In the remarks on cylinder clearance volume it was pointed out that in a Diesel engine compressor it is sometimes advantageous to have considerable cylinder clearances, and this is borne out by a study of this machine. The clearance volume in the low-pressure stage is, of course, reduced as far as possible, the method

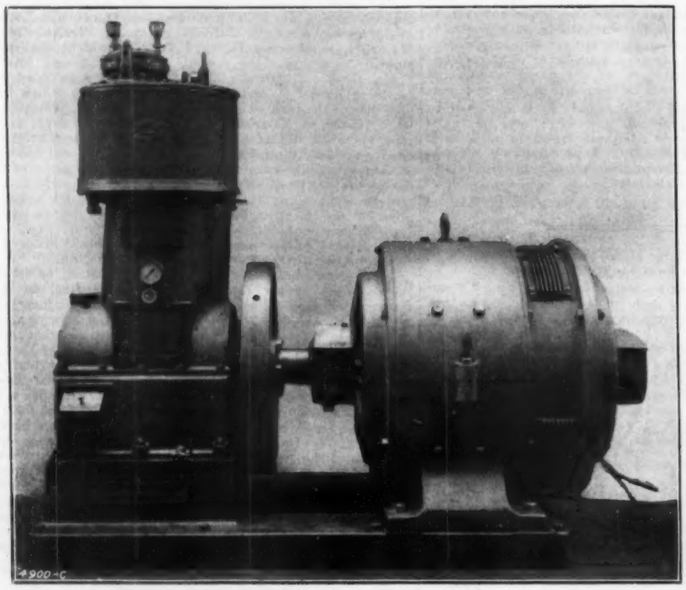


Fig. 33. Four-Stage Direct-Coupled Air-Compressor; Messrs. Peter Brotherhood, Limited, Peterborough.

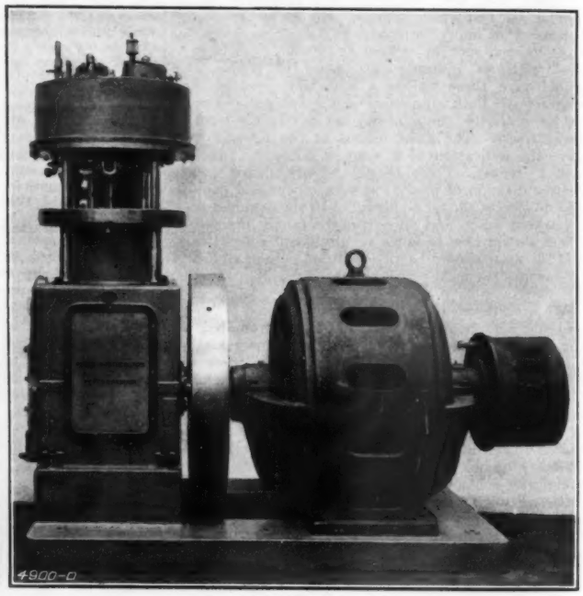


Fig. 34. Five-Stage Direct-Coupled Air-Compressor; Messrs. Peter Brotherhood, Limited, Peterborough.

* Paper read before the Greenock Association of Shipbuilders and Engineers.

AIR-COMPRESSOR TRIAL, JANUARY 11, 1915; ENGINE No. 539. BY THE GENERAL ENGINE AND BOILER COMPANY, LIMITED, NEW CROSS, LONDON.

Gauge Pressures after Cooling.				Boiler Pressure.	Back Pressure.	Counter.		Air Inlet Atmospheres.	First Stage before Cooling.	First Stage After.	Second Stage Before.	Second Stage After.	Third Stage Before.	Third Stage After.	Fourth Stage Before.	Fourth Stage After.	Circulating Water Inlet.	Circulating Water before Distiller.	Circulating Water Outlet.	Injection Water Inlet.	Injection Water Drain.	Pressure.
Stage 1.	Stage 2.	Stage 3.	Stage 4.			Revs.	Time, Mins.															
												Pump Up.										
									deg. F.	deg. F.	deg. F.	deg. F.	deg. F.	deg. F.	deg. F.	deg. F.	deg. F.	deg. F.	deg. F.	deg. F.	deg. F.	deg. F.
42	248	500	500	155	6	1,020	3–3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
46	252	580	1,000	150	7.5	2,130	7–0	57	156	109	250	101	122	83	95	78	68	81	82	78	78	60
46	260	580	1,500	150	8	3,680	11–0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
46	262	581	2,000	150	8	4,850	14–25	56	162	116	250	104	135	88	130	81	74	82	86	78	78	73
48	270	600	2,500	150	9	5,980	17–45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
49	280	640	3,000	155	10	7,040	20–45	56	165	124	150	116	150	91	152	82	76	86	93	78	78	79
												Three Hours' Run.										
49	280	700	3,500	127	10	8,030	23–40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
49	270	800	3,000	140	9.5	14,050	40–0	58	172	128	260	127	157	101	178	92	75	92	94	87	78	87
48	280	826	3,000	140	9.5	18,080	53–0	58	172	128	260	125	157	101	178	92	80	96	99	88	80	85
48	280	910	3,000	135	9	23,600	70–0	61	173	131	310	129	160	106	180	97	81	97	99	87	81	88
48	280	902	3,000	135	9	27,900	83–0	62	172	127	300	125	152	101	175	93	78	93	95	88	84	87
48	285	910	3,000	135	9	33,050	98–0	62	172	128	320	127	162	104	177	97	80	96	96	90	82	88
48	285	925	3,000	137	9	38,170	113–0	63	171	128	320	128	163	104	178	96	81	96	98	90	84	88
48	285	925	3,000	137	9	42,800	128–0	64	171	128	320	129	163	105	180	95	81	97	99	90	81	85
46	285	925	3,000	150	9	53,781	161–0	62	167	120	270	122	163	101	179	92	81	93	99	84	79	87
47	285	920	3,000	125	9	58,664	176–0	62	166	124	270	123	161	101	180	94	82	95	95	85	81	88
47	280	910	3,000	140	9	63,701	191–0	60	168	129	280	130	170	109	185	100	80	99	100	90	83	89
47	275	900	3,000	135	9	67,360	202–0	60	168	127	300	128	163	104	180	98	78	97	98	88	81	89
50	285	920	3,500	150	10	72,306	217–0	62	175	131	270	134	173	110	189	101	79	102	105	95	85	92
55	320	1050	3,500	155	10	77,276	232–0	64	182	135	275	136	178	112	192	101	81	105	108	97	88	94
58	330	1040	3,500	195	10	82,256	247–0	66	183	138	285	135	177	113	191	102	82	106	109	98	87	95

CAPACITY OF MACHINE—30 CUB. FT. OF AIR PER HOUR AT 3,000 LB. PER SQ. IN.

	Average Revolutions per Minute.	Circulating Water Lb. per Min.	Injection Water. Lb. per Min.	Average Steam Pressure. Lb. per Sq. In.	Average Exhaust Pressure Lb. per Sq. In.
Pump up	338	244	0.6	151	8
Three hours' run	331	248	0.56	146	9

of securing the piston to the rod being such that the clearance space is the minimum. The intermediate-pressure clearance, however, is very large, being, in fact, the whole volume of the intercooler tubes and connecting pipe; whilst the high-pressure clearance is also very large, being the volume of the coiled aftercooler in the jacket. Apart from the features which have already been dealt with in the notes on clearance, this arrangement allows the high-pressure valves to be located outside the water jacket—a distinct advantage—but, further, the air is cooled to a large extent after compression before it reaches the delivery valve, which cooling undoubtedly lengthens the life of the latter and reduces carbonisation troubles. The theoretical indicator diagram which results from these large clearances and "valveless intermediate" construction is given in Fig. 54, annexed, and applies to all machines of this type.

As far as the actual construction of the machine is concerned, attention may be called to the very effective cylinder jacketing, especially at the breech end of the low-pressure cylinder; also the simplicity of the high-pressure cylinder casting, with its absence of valve pockets, should be noted.

It might be noted that one small point which is open to criticism is the method of making the air connection between the jacket and the liner—viz., by the forced-in sleeves, for should a liner by any chance become scored or cracked, it might prove a little difficult to remove the sleeves so as to permit the withdrawal of the liner.

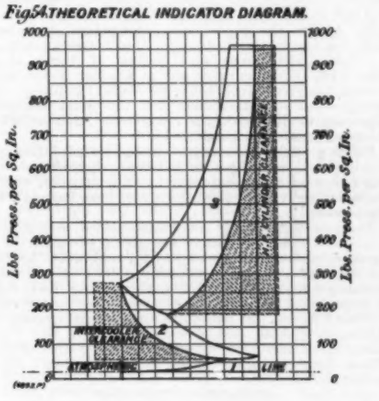
This compressor is driven from the forward end of the engine crank shaft, and the stage pressures adopted in this case are: low pressure 60 lb. per square inch, and intermediate pressure 295 lb. per square inch, when working at its full capacity against a final delivery pressure of 1,000 lb. per square inch.

In modern high-power marine Diesel engines of the two-cycle slow-running type (*e.g.*, F.I.A.T., Krupp, M.A.N., &c.) it has become usual, for various reasons, to drive the scavenging pumps by means of levers, in accordance with the well-known marine practice, and in many cases the compressor drive can conveniently be arranged in conjunction therewith.

Figs. 41 to 44, Plate XL, show the compressor arrangement which has been successfully adopted on a large British marine engine, whilst sections of the machine itself are given in Figs. 45 to 47. This compressor also embodies Messrs. Reavell's "valveless intermediate" patents, the direct passage between the intermediate-pressure cylinder and the intercooler being clearly shown in Fig. 46. The simple construction of the intercooler is worth noticing, the tubes, which are usually of copper, being expanded into the steel tube plates. When the thickness of the latter, gauge of the tubes, and method of expanding are carefully chosen, this system leaves little to be desired, and, further, it permits of a greater cooling surface being obtained, for the same overall dimensions, than would be the case were the usual ferrule system adopted. However, the tubes must be of the highest quality material and must be thoroughly tested before use, for should a tube failure occur, it would be more difficult to repair than in the case of a cooler with ferrules.

The valve arrangements are seen in Figs. 45 and 47, the low-pressure suction and delivery valves being interchangeable, whilst the high-pressure valves, which have removable seats, are also interchangeable. This, of course, reduces the number of spares which have to be carried,

Fig 54. THEORETICAL INDICATOR DIAGRAM.



in addition to obviating the possibility of mistakes when reassembling after an overhaul.

To minimise the danger, should the high-pressure cooling pipe or any other part under pressure give out, three large bursting diaphragms are provided on the water jacket (two being on the high-pressure bonnet, and one on the opposite side to the low-pressure valve box); these are ruptured, thus giving free egress to the water and air, when the pressure in the jacket exceeds a predetermined figure.

It may be remarked that the arrangement of this compressor, with the high-pressure cylinder at the bottom, is unusual, and to avoid difficulties which might otherwise result from accumulated oil in the latter, special provision is made for draining.

Another lever-driven compressor by Messrs. Reavell, as used on engines of continental design, is shown in Figs. 48 to 53, and, as in the previous machines, there are no valves in the second stage. In this case the intermediate-pressure cylinder is located below the crosshead, and a patented feature is the utilisation of the end of this cylinder as an auxiliary low-pressure cylinder. Normally the valves in the cover of this cylinder are inoperative, but when there is considerable manœuvring, and in consequence a big demand for air, such as obtains on entering port, they can be brought into action, either automatically or by hand, when, as will be seen from the sections, this cylinder delivers air into the top of the intercooler at the same time as the main low-pressure cylinder, the whole then passing to the intermediate cylinder in the usual way. By this simple means, the capacity of the compressor can temporarily be increased by about 30 per cent., which means that it will not be necessary to keep such a large auxiliary machine running as would otherwise be the case. As would be expected, very special attention has to be paid to the proportioning of such a machine, on account of the alteration to the distribution of the total work which results from such a device. In this particular machine the high-pressure valves are arranged directly in the cylinder head, access to them being obtained from the engine upper platform through the small covers on the bonnet.

Fig. 55, Plate XLI, shows a well-designed machine, constructed by Messrs. the General Engine and Boiler Company, Limited, of New Cross, London, S.E., of a type similar to those used for torpedo work, for a delivery pressure of 3,500 lb. per square inch. The capacity at this pressure and 340 r.p.m. is 30 cub. ft. of free air per hour. The machine is a four-stage steam-driven type and is a self-contained unit, the inverted steam cylinder, as will be seen, being placed beneath the air cylinders. Apart from the very compact arrangement which is thus obtained, the drive is direct, so that the stresses in the connecting rods, for example, are much less than they would be with the "side-by-side" arrangement. Another noteworthy feature in the design is the provision of a separate cylinder for each stage of compression, instead of having recourse to differential pistons, which latter arrangement, although possessing many advantages, is decidedly inferior from a thermal point of view, on account of the reduced cooling surface per unit of heat generated. In addition to the effective cooling resulting from the arrangement adopted, intercoolers are provided, and, further, a distiller is fitted which provides pure water for injection into the air cylinders.

The remaining diagrams (Figs. 56 and 57) and the Table above show the results of an exhaustive trial carried out by the builders on one of these machines. The curves reveal many points of interest, whilst an idea of the distribution of work through the machine can be obtained from the cards, which show a mechanical efficiency of about 68 per cent.—a very satisfactory result considering the large amount of piston friction and the two connecting rods, &c. The card from the fourth stage would seem to indicate a large cylinder clearance, but it may be pointed out that sometimes the indicator itself adds quite a large percentage clearance to a small high-pressure cylinder—especially when connections are long, due to the necessity of passing through a water jacket. Regarding the intercooling effect as shown by the curves, it might be thought that improvement could be effected. In practice, however, a long continuous run at full pressure is very seldom required of compressors of the charging type—therefore the intercoolers need not be of such dimensions as those required for a continuous duty machine. Again, the question of economy is of less importance.

With the increasing number of applications of high-pressure air, and especially with the growth of the Diesel engine industry, more attention is being paid to the design of high-pressure machines, and in view of the scarcity of trustworthy literature on this subject, the foregoing brief outline of some of the points which arise may serve a useful purpose. In conclusion, the writer would express his indebtedness to the various builders who have so kindly placed drawings and other information at his disposal.

PROJECTED FREE HARBOUR IN STOCKHOLM.—The Swedish capital is now about to follow the example set by the second and third largest towns of the country in the matter of a large, up-to-date free harbour. A special committee appointed some six months ago has now completed its report, which takes the shape of a definite plan, and it is understood that the matter will be proceeded with as speedily as possible.

THE NEW RHENISH-WESTPHALIAN COAL SYNDICATE.

According to what has transpired, the new Rhenish-Westphalian Coal Syndicate, as it is generally called although in reality it is in all main points a continuation of the present syndicate, comprises an aggregate of 101 concerns with separate allotments. The allotment comes under four heads, the sale, or what is the real allotment for coal, the coke allotment, the briquette allotment, and the home consumption allotment. Some of the figures throw an interesting light on the magnitude of the Rhenish-Westphalian coal industry, as will appear from the appended particulars of the coal sale allotment of some of the largest concerns :—

Crown coal mines	... ...	6,000,000 tons.*
To this must be added		
Hibernia	... ...	5,813,500 ,,
The Gelsenkirchen Company	...	9,995,700 ,,
,, Harpen Company	... ...	7,788,800 ,,
,, Phönix Company	... ...	3,190,000 ,,
,, Rheinpreussen Company		3,000,000 ,,
,, Deutsch-Luxemburg Company	... ...	3,635,000 ,,
,, Constantia Company	...	2,762,800 ,,
,, Ewald Company	... ...	2,449,000 ,,
,, Graf Bismarck	... ...	2,326,600 ,,
,, Essenor Coal Company	...	2,325,000 ,,
,, Arenberg Company	...	2,243,000 ,,
,, Gutehoffnungshütte	...	2,116,600 ,,

* Gradually rising to 6,815,000 tons for 1920–1.

In addition, it may be mentioned that 33 concerns have an allotment (in a few cases only extended towards the end of the term of the new syndicate) of 1,000,000 tons or more, but less than 2,000,000 tons.

It is a very near thing between the Crown and the Gelsenkirchen Company, inasmuch as the latter owing to its allotment for its own consumption of 2,085,000 tons, actually beats the Crown in the aggregate, 12,080,000 tons, against the Crown aggregate of 11,813,500 tons but this only applies to the first year, inasmuch as the Crown allotments increases 400,000 tons the second year of the agreement, whereas that of the Gelsenkirchen Company remains unaltered. The Crown certainly has 450,000 tons reserved for State uses, but they are included in the sale allotment.

In the matter of coke allotment, however, the Crown holds a decided lead :—

Crown (with Hibernia)...	...	3,512,000 tons.
The Harpen Company ...	...	2,050,000 ,,
,, Gelsenkirchen Company	...	1,826,808 ,,
,, Constantia Company	...	1,200,000 ,,

All other coke allotments are below 1,000,000 tons.

About 30 coal mining concerns have briquette allotments, the largest being :—

The Essener Coal Company	...	811,000 tons.
,, Deutsch-Luxemburg Company	... ...	710,550 ,,
,, Harpen Company ...	...	417,000 ,,

Conspicuous in the list of consumption allotments are :—

The Deutscher Kaiser ...	...	2,723,000 tons.
,, Phönix Company ...	...	2,473,400 ,,
,, Gelsenkirchen Company	...	2,085,000 ,,
,, Deutsch-Luxemburg Company	... ...	2,031,300 ,,
,, Wied Krupp Company	...	1,992,700 ,,
,, Gutehoffnungshütte	...	1,635,200 ,,

GERMAN ELECTRIC POWER PLANT IN SOUTH AFRICA.

The following notes on German electric power plant in South Africa are taken from a recent address on "The Power Supply of the Rand," by the president of the South African Institution of Engineers, a full report of which has appeared in the *South African Mining Journal* :—

"British engineers, the president said, are no less skilful than their German competitors, and, in his experience, the merits of German design have often been considerably overrated. It is not uncommon to meet with German plant in South Africa which betrays every evidence of scientific knowledge from a purely theoretical point of view, but is hopeless when viewed from a practical standpoint. The winding of a large alternator, for example, is complicated enormously merely to gain some slight benefit in rating, but at the sacrifice of features which are infinitely more valuable to those who will operate and maintain the finished machine. In this connection the following instances, taken from the experience of a large electric power supply company, were cited to show that although two leading German firms were somewhat ahead of British firms in developing electrical plant of the size and voltage required for large power schemes in South Africa, the German firms made many mistakes, and had still to acquire much experience at the expense of their customers :—

"Six 4,000-k.v.a. alternators made by a German firm had to be entirely rewound, and seven 12,000-k.v.a. alternators (including a spare stator) had to be entirely rejointed. The smaller machines were originally wound for 10,000 volts, so as to avoid the use of step-up transformers, and the design of these high-tension windings was totally inadequate. Lightning made short shrift of them, but, in any event, their life could not have exceeded a few years. On the largest sets the joints between slot bars and end connections overheated very soon after the machines went into commission, and caused a long succession of serious and expensive breakdowns. The design of these joints had to be radically modified, involving a most tedious and costly programme of work.

"Numbers of sub-station transformers of 1,000 k.v.a. and 500 k.v.a. capacity, made by the same firm, proved incapable of standing the stresses imposed at times of fault on consumers' circuits. The method of clamping the coils had to be entirely re-designed.

"The high-tension switch gear for 40,000, 20,000 and 10,000 volts proved lamentably deficient when called upon to meet working conditions on a system of this size and type, and it would be difficult to exaggerate the seriousness of the consequences which ensued. No scheme in the world has had to face such serious switch trouble, and, when approached, the makers could suggest no better remedy than a duplication of all important switches at the expense of the power company and to the profit of the makers. Needless to say, this course was not pursued. The trouble has been almost entirely removed by the application of engineering common-sense to the experience gained in practice. It is quite clear that in those days this firm knew very little indeed about the design of high-tension switch gear for large systems. They were quite satisfied to proportion up the dimensions of a low-tension switch.

"When asked to advise on the problem of lightning protection, experts (so-called) were sent out by the German firm to report, but, despite all their theoretical argument, nothing of practical value was produced. This problem, like many others which arise in commercial engineering, had to be solved by weighing up experience and avoiding fantastic proposals.

"Although the turbines were a good job in many respects, heavy maintenance charges were incurred on account of defective blading. There is no doubt that the firm had but little knowledge respecting the materials best suited to stand the peculiar conditions to which turbine blades are subjected. At one time accumulation of these blading troubles very nearly involved curtailment of supply, but it became clear that some of the defects which were most pronounced originated from faulty design, and these have now been rendered less acute.

"The steam pipes, valves and lagging were a most shoddy job. The flanges on the steam pipes were expanded on without riveting, and a serious accident was but narrowly averted at one power station due to the expansion and consequent withdrawal of one of these flanges. It has been necessary to re-expand and rivet on every flange of every steam pipe at two power stations, and the whole of the lagging, which had begun to break away before the pipes were dismantled, had to be scrapped and replaced by material of better quality.

"The arrangement and design of three of the electrically-driven compressors at another power station is a disgrace, and involves excessive cost in upkeep. The arrangement of intercoolers and pipe-work renders it necessary to dismantle the compressor itself before the intercoolers can be cleaned.

"Seven 12,000 k.v.a. three-phase transformers made by another German firm had to be entirely rewound. The original windings were deficient in insulation, and the surface of the copper conductors had been burned during the process."

The president of the Institution added that while he was quite ready to admit the merit of much of the German workmanship and design, and while he could not but admire the organising power displayed by German concerns, he did not think they had reason to be proud of the record of the plant they had installed in South Africa. It was quite certain that leading consulting engineers and manufacturers in the United Kingdom would have avoided many of the mistakes which South African power companies had had to correct.

NOTES FROM THE UNITED STATES.

Philadelphia, November 1.

Prices in every kind of iron and steel have again advanced during the past week. The advances in pig-iron range all the way from 1 to 3 dols. per ton. The Allied countries have placed very large orders for steel during the latter half of next year. Coke has advanced to 8 dols. for spot supplies. The serious difficulty in the situation is the shortage of cars to carry material. Car shortage is complained of everywhere. Prices have reached a dangerously high level. Nearly all large buyers of basic steel are now in the market for large quantities. Great Britain has completed her arrangements for paying the insurance rate on about 100,000 tons of Bessemer at Alabama furnaces. Many furnaces have recently declined orders for the last half of next year. Forging billets have advanced to 75 dols. England is in the market for all the soft billets it can purchase. Large Eastern railroads are negotiating for rails for 1918 delivery. Car orders are being crowded in faster than builders are willing to arrange for their acceptance; all kinds of cars are wanted, including steel hoppers, gondolas, tank cars and standard freight cars. Large requirements for structural steel are coming before the market. A recent order is for 25,000 tons for shipyard extension at Newport News. Pittsburg makers of merchant steel are advised by France and England that they will take all the munition steel they can furnish for an indefinite period. All the tin-plate mills have sold everything they can deliver for the first half of next year. There are at present inquiries on the market for export for 4,000,000 boxes of tin-plate. The French Government are anxious to place orders for 30,000 tons of all grades of wire products for delivery to be made this year. Urgent requirements for pipes are being forced upon the market to build several hundred miles of pipe-line. Coke is soaring in price. It is impossible to make any predictions. There is great urgency for track equipment such as nuts and bolts. The urgent demand for ship plates continues to be far beyond the capacity of mills.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—So far as the Glasgow pig-iron warrant market is concerned, conditions remain unchanged, with little prospect of any revival of business for some time to come.

Scotch Steel Trade.—Conditions in the steel trade run practically on the same level as a week ago, the demand being insatiable and the output enormous, though still insufficient to meet the purposes of the British and the Allied Governments. Efforts to increase the output receive every consideration at the hands of steelmakers in the West of Scotland. This would give the bigger deliveries which are so very urgently required, particularly at a time when the pressure is making itself felt as never before. Were this in itself not a sufficient deterrent to export trade, the further restrictions of the Ministry of Munitions would surely constitute such. Indeed, the demands of Class "A" and Class "B" are so very insistent that Class "C"—to which ordinary mercantile business belongs—is completely crushed out now. Enormous quantities of shell bars are being turned out from day to day, while the tonnage of sectional material and material for ordinary war purposes is likewise a very heavy item. The difficulties of licences have had a certain effect on export rates, but at the moment ship plates run about 14*l.* 15*s.* per ton; boiler plates, 14*l.* 15*s.* or thereabouts; and angles, 14*l.* 12*s.* 6*d.*

Malleable Iron Trade.—So steadily are things moving in the malleable iron trade, and so well are the order books filled with good contracts, that brisk business is assured for a considerable period ahead, and that at specially satisfactory rates. Most of the output of the iron departments is being placed at the disposal of the Allied Governments, while that of the steel departments is being reserved for the use of the home Government. To keep this up, naturally, all the mills are running at top speed. For "Crown" bars the price for home delivery is now 14*l.* 12*s.* 6*d.* per ton, less 5 per cent., while even this rate has been exceeded for good export business.

Scotch Pig-Iron Trade.—Without doubt the outstanding feature of the local pig-iron trade is the fact that Government has now got so complete and secure a control of all that is being done that nothing is available for other than the purposes of the war. The demand, therefore, for all grades, and notably for hematite, continues unabated. Just as has been the case for some months now, the local steel works rapidly absorb the entire output of hematite, while the other sorts are being as readily disposed of, despite the scarcity of No. 1 foundry iron.

Skilled Engineers and the Army.—Under existing circumstances, which render it absolutely essential that a sufficient number of skilled men should be retained in all the engineering shops employed on Government work, the anxiety which has been felt regarding the position of the men has now been allayed. The recent visit to London of a representative deputation is likely to have good results, the report of the interviews with the Ministry of Munitions, various Scottish members of Parliament interested in the question, and the Man-Power Board, having been submitted to meetings of the shop stewards in the works concerned a few days ago. At these meetings resolutions were unanimously passed which will in due course be submitted to the different Government departments.

Austrian War Profits.—The Austrian Arms Factory, Steyr, has benefited from the war to a very large extent. The year ended June 30, 1915, showed a net profit of 6,420,000 kronen, against 2,790,000 kronen for the preceding year, the dividend being raised from 19 to 25 per cent. In the year ended June 30, 1916, the net profit amounted to 17,710,000 kronen and the dividend was 50 per cent. The Austrian Arms Factory is the largest rifle-manufacturing concern on the Continent, employing some 22,000 hands; it has always been well managed, and the writings-off have been ample, so that factories and plant, in spite of large recent extensions, only stand booked at 16,850,000 kronen. In spite of higher wages and dearer raw material, prices have maintained a reasonable level, and are lower than those prevailing in Germany. The company is considering the putting down of a motor-car factory, at an outlay of some 30,000,000 kronen, capable of turning out 10,000 motor cars in the year. The reason for this new departure is to secure employment for the employees at a time when the demand for arms has again fallen to normal figures. (1 krone = 10*d.*)

Fuel Briquetting in the United States.—Fuel briquetting is still in its infancy in the United States, and it may not assume large proportions for many years to come. The production of fuel briquettes in 1915 amounted to 221,537 short tons, valued at 1,035,716 dols.; those figures were by about 10 per cent. smaller, both in bulk and in value, than those of 1914, which were the highest so far recorded. Looking at the number of plants manufacturing fuel briquettes we find ("Mineral Resources of the United States, 1915"; II : 1, by C. E. Leaher) that this number had risen to 21 in 1911, but had declined to 15 since. Anthracite is too cheap, generally, the briquette plants are too widely distributed, and people in the Eastern States do not take much to the briquettes, especially when they are made with coal-tar as binder and when smoky. Yet the average output of the plants is now considerably larger than it was in 1911. The materials used are anthracite, anthracite culm, bituminous slack, lignite, oil gas residue in various mixtures, and coal-tar pitch, asphaltic pitch, petrolastic cement and organic binders.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—There was a further decline last month in the amount of traffic dealt with at the port. The tonnage received was 292,364 tons, as compared with 365,103 tons for the same month of 1915, making the total for the 10 months of the year 2,821,563, against 4,069,176 in 1915. The foreign exports, exclusive of coal for the purposes of the Admiralty and Allied Governments, totalled 120,733 tons, being a reduction on October of last year of 137,989 tons. For the year up to date the aggregate exported is 936,604 tons, a falling-off of 1,270,651 tons. The bulk of the trade last month was with France and Italy, and the remainder went to Sweden, Denmark and Holland.

South Yorkshire Coal Trade.—All grades of manufacturing fuels are wanted in heavy deliveries, but, generally speaking, railways, works and all important industrial concerns have no difficulty in getting full supplies, and the former are taking extra quantities for the purpose of adding to their reserves. Gas fuels are going away on a large scale on contract account. The house coal market is steady. The general export trade shows some slight falling-off, except to Allied Powers. There is a scarcity of ships, and this has caused a lot of forced selling at the ports. Neutral sales are fully 9*s.* per ton higher than inland quotations. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls 7*s.* 6*d.* to 8*s.* 6*d.* per ton.

Iron and Steel.—The general position of the Sheffield industries is well maintained by the steady level of output. All branches are working at the maximum pressure, the bulk of the manufactures being work of national importance. The material market presents few new features, the revised regulations and prices of iron and steel meeting with general acceptance. The changes made are relatively unimportant. There has been little heavy buying of common irons, especially of Lincolnshire foundry quality, but the demand for hematites, particularly the special brands, is still exceedingly keen. Steel deliveries are increasing, though the Swedish shipments have again fallen off to a considerable extent. Scrap metal buying is brisk. Heavy steel scrap easily fetches the maximum price of 5*l.* 10*s.*, turnings 2*l.* 15*s.*, and special turnings 3*l.* 15*s.* Considerable work has been put in hand for one of the largest railway undertakings in the country. Tramway orders are also on a large scale. File and saw makers continue to receive large contracts, both for war and industrial purposes. The cutlery trade has many Army and Navy orders on hand, but manufacture has not been facilitated by the recent prohibition of the importation of celluloid. As this is the favourite hafting material for table knives, it is probable a large proportion of the export business with the Colonies will have to be foregone. The overseas business is represented in indents for tools, saws, sheep shears, machetes, hammers, wire rope, steel and cutlery.

Steel Firms Amalgamation.—A notable business development is announced in the scheme of the directors of Messrs. Samuel Fox and Co., Stocksbridge, and Messrs. Steel, Peech and Tozer, Limited, Rotherham, two of the largest steel firms in the country, representing hundreds of thousands of pounds capital, to amalgamate. Both the firms have an enormous output of all kinds of steel, and specialise in rails, tyres and axles, springs, heavy steel castings, &c. According to a circular which has been issued by Mr. J. G. Jeffery, the secretary of Messrs. Samuel Fox and Co., the proposal to amalgamate will be laid before the shareholders of this company at the annual meeting to be held on the 17th inst. It is stated the union of interests will ensure the mutual benefit of both companies, and has already been provisionally agreed upon. The arrangement, which is to take effect as from July 1, 1915, has been based upon an independent valuation of the assets of both companies and the ascertainment of the profits. It is proposed to amalgamate under a suitable title, with an agreed participation of each company in the capital and profits. The movement is regarded in Sheffield as an "after war trade" scheme. It is only a portion of a big plan to capture markets Germany formerly held, and the enterprise may include more firms. The object is to turn out larger quantities of the cheaper qualities of steel, which the Germans have up to now produced with so much success against us. Messrs. Steel, Peech and Tozer have on hand the putting down of 50 new furnaces. Developments are also taking place at the works of Messrs. Fox. The full scheme, however, will not mature until the close of the war.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is on a moderate scale. Home consumers are well covered for the present, and are not particularly keen buyers for early delivery. Customers in Scotland have made their purchases for this month, and as yet are not permitted to buy for December delivery. Sanction, however, may be conceded at any time, and it will probably be promptly followed by a rush of orders for delivery north of the Tweed. There is a heavy demand for shipment. Fairly good sales to our Allies are reported, and under exceptional circumstances licences for exports of small lots to Scandinavia are obtainable. For home consumption, No. 3, No. 4 foundry and No. 4 forge all stand at 87*s.* 6*d.*, and No. 1 is 91*s.* 6*d.*; whilst for shipment to the Allies, No. 3 is 97*s.* 6*d.*, No. 4 foundry 96*s.* 6*d.*, and No. 1, 102*s.* 6*d.*; and for export to neutral countries No. 3 is put at 105*s.* and No. 1 at 110*s.*

Meeting of Pig-Iron Consumers.—Under the auspices of the National Light Castings Association a meeting of pig-iron consumers was held at Middlesbrough this week. The proceedings were private, but it is understood that the allocation of supplies of iron were discussed, with a view to devising improved means of distribution. Arrangements were made to collect certain information, and the meeting was adjourned for a fortnight. Many consumers on the North-East Coast consider that the different iron-producing districts should be more self-supporting, and incline to the view that habitual users of Cleveland pig have a prior claim to supplies over consumers who have recently come into the market.

Hematite Iron.—Little new is ascertainable concerning the East Coast hematite branch of the staple industry, but business is not quite so difficult to arrange as it has been although many makers are sold as far ahead as they care to commit themselves. The output is to be increased almost immediately by the blowing-in of an additional blast-furnace. Home consumers are well bought, and licences for despatch to our Allies are granted more freely. Large quantities are going to France, and fairly substantial sales to Italy are understood to have been made. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Stocks and Shipments of Pig-Iron.—Stocks of pig-iron are very low. The quantity of Cleveland pig in the public warrant stores here has been stationary at 4,434 tons since the 23rd of last month, and consists of 4,398 tons of No. 3 quality, and 36 tons of other kinds of iron deliverable as standard. Shipments of pig-iron from the port of Middlesbrough so far this month are officially returned at 10,395 tons, as compared with 17,766 tons to the same date last month, and 16,026 tons for the corresponding part of November last year.

Coke.—Coke continues in good demand for local use, and values of the qualities required are well maintained, notwithstanding the plentiful supply. The opinion prevails that the surplus on the market will be taken up in the very near future. Average blast-furnace kinds remain at 28*s.* at the ovens, and up to 30*s.* 6*d.* at the ovens is still quoted for qualities low in phosphorus.

Foreign Ore.—So far this month the quantity of foreign ore imported to the Tees is officially given at 63,921 tons.

Manufactured Iron and Steel.—Manufacturers of finished iron and steel are too busily employed to pay much attention to the rather numerous inquiries in the market. Rather considerable quantities of mercantile marine material are being turned out, and there is little abatement in the pressure for delivery of Government work. Prices are very strong. For home use common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles 13*l.* 15*s.*; packing iron (parallel), 11*l.*; packing iron (tapered), 13*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; and heavy steel rails, 10*l.* 17*s.* 6*d.* For shipment, the following are among the principal market quotations:—Common iron bars, 15*l.*; steel bars, 16*l.*; steel ship plates, 13*l.* 10*s.* to 18*l.*, according to diameter; steel sheets (singles), 20*l.*; steel sheets (doubles), 22*l.*; steel boiler plates, 20*s.* above ship plates; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; heavy steel rails, 11*l.* 5*s.*; packing iron and steel (parallel), 12*l.*; and packing iron and steel (tapered), 14*l.* 5*s.*; all f.o.b.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam coal trade has been quiet in all its branches. Tonnage arrivals have been heavier and shipments have shown a corresponding increase, but with excessive standing stocks and colliery owners having to stop pits, values have shown an all-round weakness and sellers have readily made reductions to secure spot orders and release trucks. The best Admiralty large steam coal has been, to some extent, nominal; secondary descriptions have made 31*s.* to 32*s.*; Monmouthshire Black Veins, 31*s.* to 32*s.*; ordinary Western Valleys, 30*s.* to 31*s.*; Eastern Valleys, 29*s.* to 30*s.*; best bunker smalls, 21*s.* to 22*s.*; and cargo smalls, 19*s.* to 20*s.* In bituminous coal, best households have made 25*s.* 6*d.* to 26*s.* 6*d.* per ton; No. 3 Rhondda large, 31*s.* to 32*s.*; smalls, 25*s.* to 27*s.*; No. 2 Rhondda large, 27*s.* to 28*s.*; and No. 2 smalls, 19*s.* to 20*s.* per ton. The latest quotation for patent fuel has been 40*s.* to 42*s.* 6*d.* per ton. Special foundry coke for export has brought 62*s.* 6*d.* to 65*s.*; good foundry coke, 57*s.* 6*d.* to 60*s.*; and furnace coke, 47*s.* 6*d.* to 52*s.* 6*d.* per ton.

Western Trade Matters.—The Main Colliery Company has decided to present to the shareholders accounts for a period of 18 months ended December 31. The financial position of the undertaking has improved, and at a meeting at Bristol the chairman (Sir G. White) stated that there was now no charge of any kind upon the undertaking. When the accounts for 1915–16 were presented, a final dividend for the financial year would be recommended.—The receipts of the Sharpness New Docks and the Gloucester and Birmingham Navigation Company for the past half-year show a decrease of 3,967*l.* Grain imports for the half-year exhibit a falling-off of 4,208 tons, timber imports a falling-off of 40,040 tons, and sundries a falling-off of 20,966 tons. Under these circumstances, the directors regret that no dividend can be paid upon the "A" preference stock.—Tonnage difficulties continue to be experienced by colliery managers; advanced rates have been demanded for Spanish ports, and a rise of 2*s.* 6*d.* per ton has been conceded for Alicante. As a result of tonnage difficulties, coal prices have dropped 10*s.* per ton during the last few weeks, second Admiralties and Monmouthshires having declined from 40*s.* per ton to 30*s.* per ton.—Mr. Edgar Evans, of the Treforest Mining School, has been engaged by Lord Rhondda to make chemical researches for the Consolidated Cambrian, Limited.—The steamer Arthur Balfour, built in 1903, and 3,849 tons gross, has been sold to Messrs. Instone and Co., Limited, Cardiff, for 100,000*l.*—The steamer Reynolds, built at Sunderland in 1898, and 5,100 tons deadweight, has been purchased by the Britain Steamship Company, Limited, and has been renamed the Chertsey.—The Greek steamer Demetrios Inglesis, formerly the Red Jacket, of Cardiff, built in 1894, and 3,100 tons deadweight, has been sold for 24,000*l.*; she was disposed of in September, 1913, for 8,000*l.*—The business of A. Wulfing and Co., manufacturers of "Sanatogen" and "Formamint," has been purchased from the Board of Trade by Lord Rhondda and associates; the purchase price was 360,000*l.*, and the buyers were Mr. A. Michelson, Mr. J. Stanley Holmes and Mr. J. Gower Berry.—The profits of the Barry Graving Dock and Engineering Company, Limited, for 1916, after providing for interest on debentures and war profits tax, were 20,216*l.*, as compared with 26,961*l.* in 1915, 19,550*l.* in 1914, 25,295*l.* in 1913, and 19,670*l.* in 1912. The dividends on the ordinary capital come out as follow for the five years:—1912, 9 per cent.; 1913, 10½ per cent.; 1914, 10 per cent.; 1915, 11 per cent.; and 1916, 10 per cent. The company is now a private one, the bulk of the share capital being owned by the Cardiff Channel Dry Docks and Pontoon Company, Limited.—The Rhymney Iron Company, Limited, has declared an interim dividend upon its ordinary capital at the rate of 6 per cent. per annum.—The directors of the Gwaun-Cae-Gurwen Colliery—one of Lord Rhondda's recent acquisitions—have decided to carry the dividend on the ordinary shares for 1916 to 20 per cent. per annum. The corresponding dividends for the five preceding years were as follows:—1911, 1912, 1913 and 1915, 10 per cent. per annum; 1914, 5 per cent. per annum.—It has been found more convenient to undertake at Avonmouth the maintenance work of the Avonmouth dock formerly carried out by the engineer's department at the Underfall yard, Cumberland-road. A portion of the land and premises at the Underfall yard is therefore no longer required, and offers have been invited for a lease of the portion of the yard which can be conveniently given up. An application for a lease of a portion of the land has been received from Messrs. P. and A. Campbell—for 14 years, at 250*l.* per annum for the first seven years and at 265*l.* per annum for the remaining period.—It is proposed to purchase a plot of land at Portishead for 51,561*l.*, for dock developments.—The steamer Rachel, built in 1910, and 3,580 tons gross, hitherto owned by Messrs. J. C. Gould and Co., Cardiff, has been sold to the Lewis Steam Navigation Company, Limited, for 130,000*l.*

THE UNITED STATES NAVY.—The United States Navy Department has opened bids for forgings for 24 of the 50 14-in. guns with which the new American battle-cruisers are to be armed. A complete set of forgings will weigh 100 tons. There were two competitors for the contracts upon the occasion, viz., the Bethlehem Steel Company, which bid 35½ cents per lb. for the whole of the forgings required, and the Midvale Steel and Ordnance Company, which offered to furnish 12 guns only at 35 cents per lb. It is understood that the 24 guns will be divided between the two competing companies.

PERSONAL.—The offices of the "Perfecta" Boiler Circulator, Limited, are now at 39, Victoria-street, London, S.W., and not at 25, Victoria-street, as recently stated by us. They left the latter address some months ago.—On November 18 the offices of both the Worthington Pump Company, Limited, and of Messrs. James Simpson and Co., Limited, will be temporarily transferred to Queen's House, Kingsway, London. This change is due to the fact that the War Office has requisitioned the present offices of the two companies at India House.—Mr. Sherard Cowper-Coles informs us that he has severed his connection with the Homogeneous and Coating Company, of 1 and 2, Old Pye Street, Westminster.—Mr. Wm. Newton Weston, M.I.Mech.E., has been appointed a director of Messrs. Herbert Morris, Limited, Loughborough. He will continue to hold the position of secretary which he has occupied for the past nine years.

CONTRACTS.—Simon-Carves, Limited, of Manchester, have just completed the cementation of the two shafts of the Llay Hall Colliery, Wrexham, North Wales, where excellent results have been achieved. Both the upcast and downcast shafts, which were originally giving off large feeders of water, have been carefully treated, and the brickwork and tubbing made quite dry; the pumping of the shaft water has now been dispensed with, and the only water now to be handled is that coming from the underground workings. The work has been carried out without the slightest interruption to the coal drawing. The neighbouring colliery of Rhosddu, owned by the Wrexham and Acton Collieries, Limited, has just placed a similar contract with Simon-Carves, Limited, for the treatment of its shafts, where very considerable feeders of water have been coming from the tubbing. Simon-Carves, Limited, were also the contractors for the freezing and sinking through the loose grounds for the Llay Main Collieries, Limited, at their new shafts in North Wales.

THE McMEANS AND BOSLER CUTTING-OFF MACHINES.

CONSTRUCTED BY THE SOUTHWARK FOUNDRY AND MACHINE COMPANY, PHILADELPHIA, PA., U.S.A.

(*For Description, see Page* 477.)

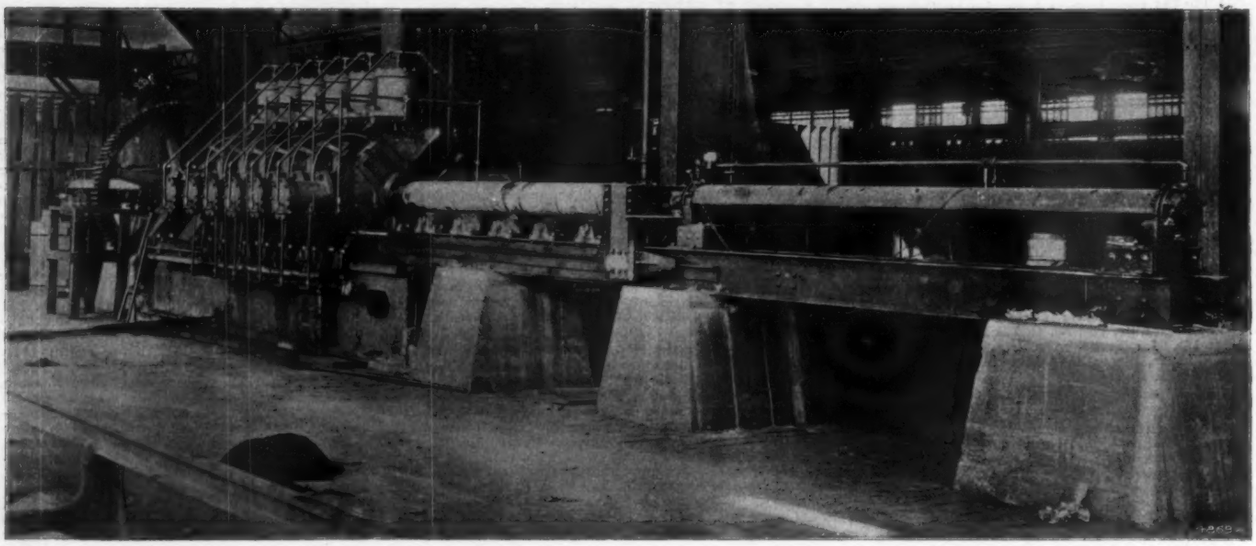


FIG. 9. SIX-HEAD CUTTING-OFF MACHINE IN OPERATION.

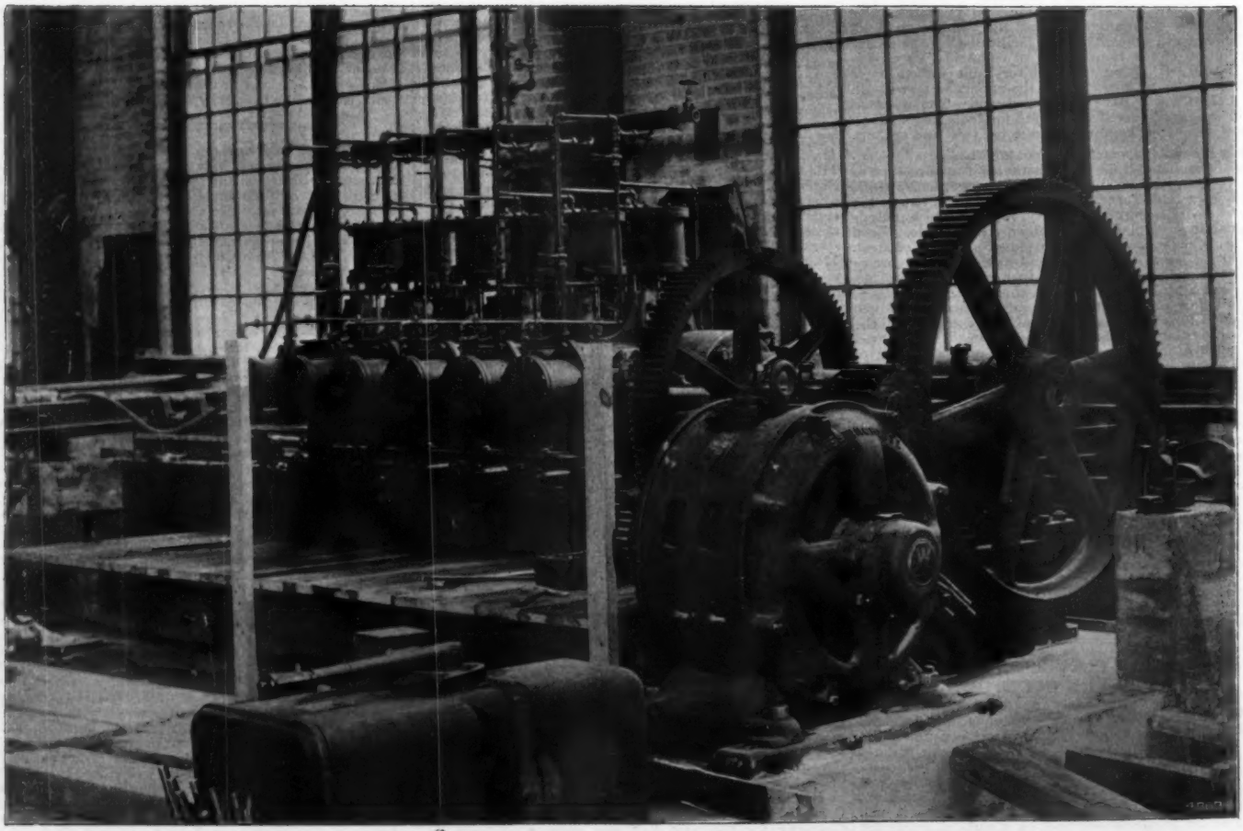


FIG. 10. SIX-HEAD CUTTING-OFF MACHINE UNDER ERECTION.

HIGH-PRESSURE AIR-COMPRESSORS.

(*For Description, see Page* 480.)

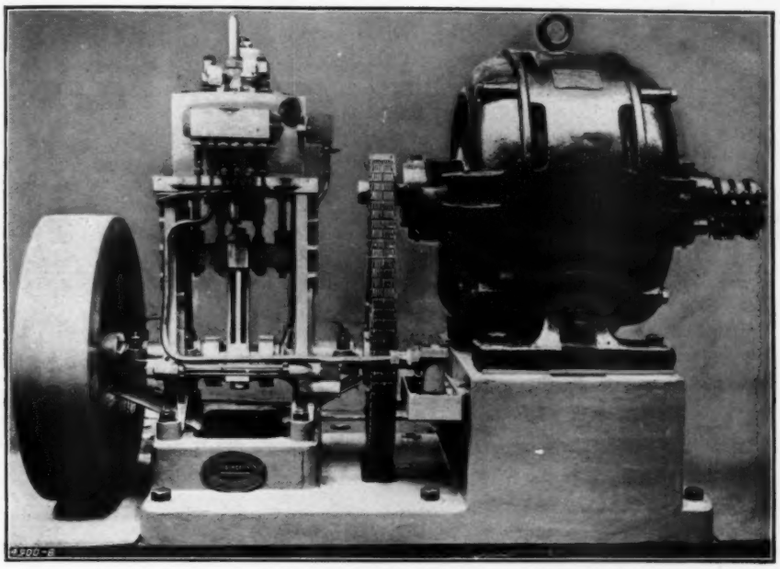


Fig. 30. Three-Stage Compressor, to Compress 600 Cub. Ft. Free Air per Hour; Messrs. Peter Brotherhood, Limited, Peterborough.

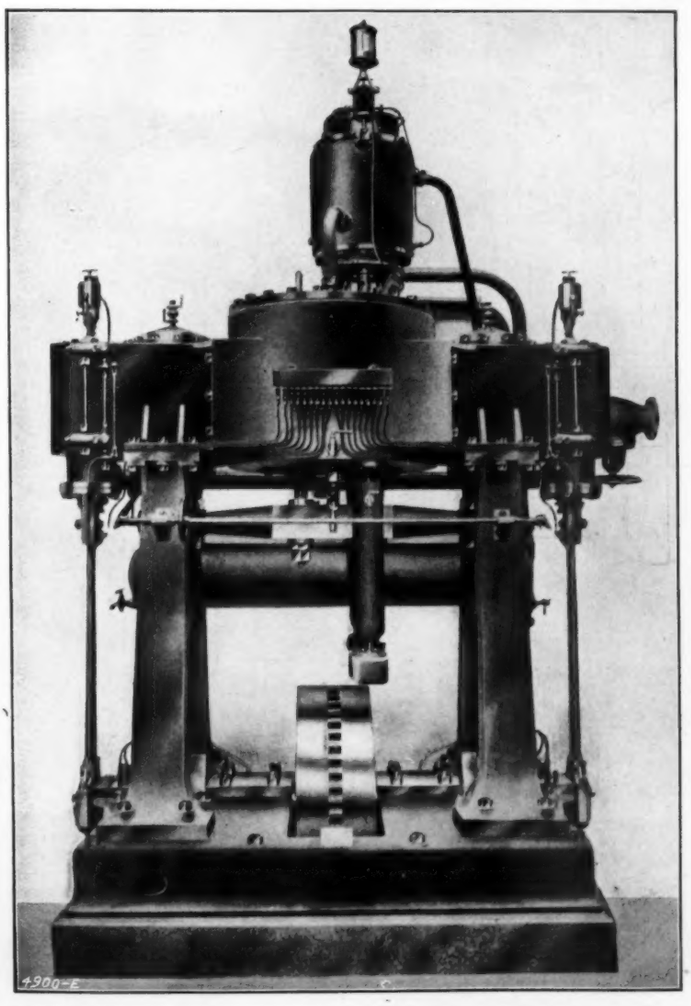


Fig. 31. Five-Stage Compressor, to Compress 10,000 Cub. Ft. Free Air per Hour; Messrs. Peter Brotherhood, Limited, Peterborough.

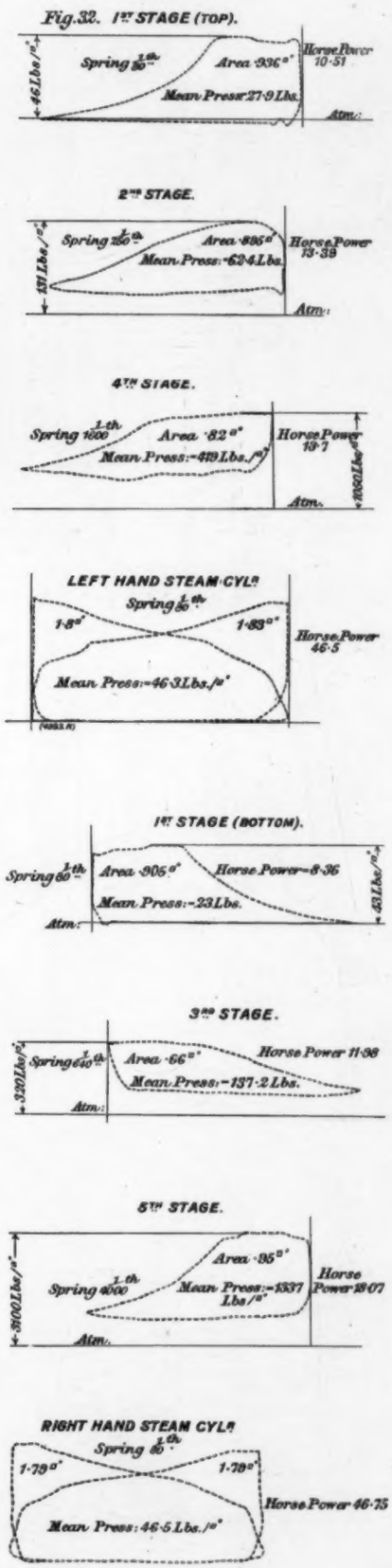


Fig. 32. Complete Set of Indicator Diagrams from Compressor shown in Fig. 31.

(*To face page* 480.)

HIGH-PRESSURE AIR-COMPRESSORS FOR DIESEL NTE

CONSTRUCTED BY MESSRS. REAVELL & CO.

(For Descrip[tion] see Pa[ge])

Fig. 35.

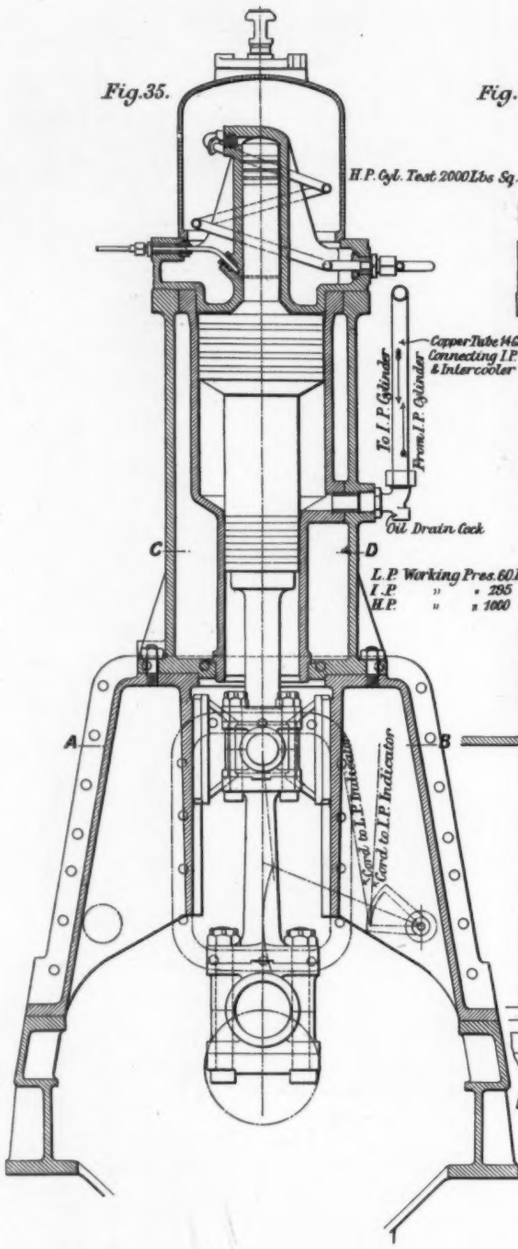

H.P. Cyl. Test 2000 Lbs Sq. In.
To I.P. Cylinder
From I.P. Cylinder
Copper Tube 14 Gauge Connecting I.P. Cyl. & Intercooler
Oil Drain Cock
C
D
L.P. Working Pres. 60 Lbs/Sq. In.
I.P. " " 295 " " "
H.P. " " 1000 " " "
A
B
Lead to L.P. Indicator
Lead to I.P. Indicator

Fig. 36.

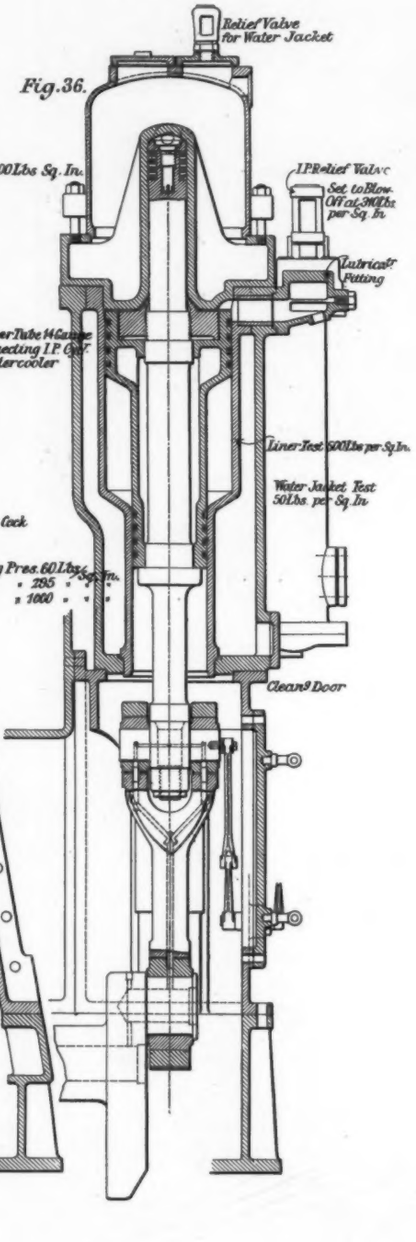

Relief Valve for Water Jacket
I.P. Relief Valve Set to Blow Off at 340 Lbs per Sq. In.
Lubricator Fitting
Liner Test 500 Lbs per Sq. In.
Water Jacket Test 50 Lbs. per Sq. In.
Cleaning Door

Fig. 39.

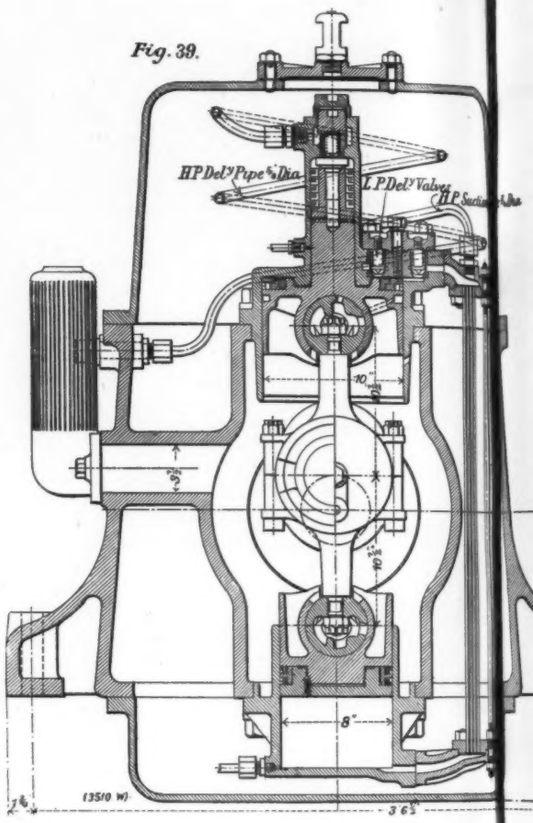


Fig. 48.

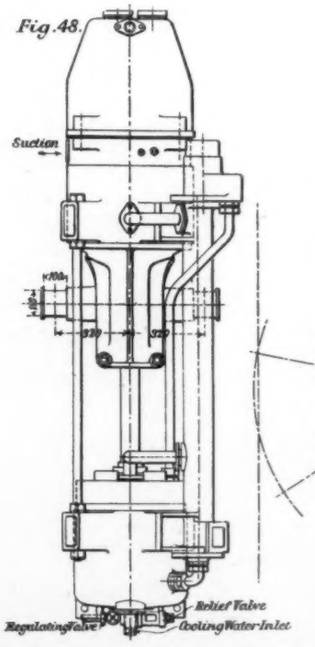


Fig. 49.

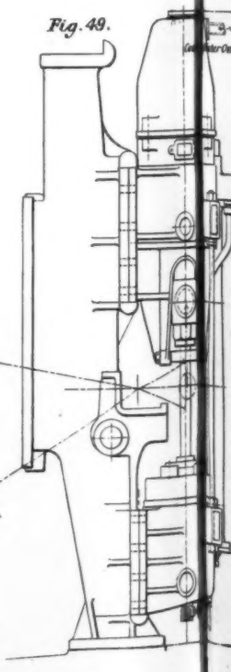


Fig. 37.

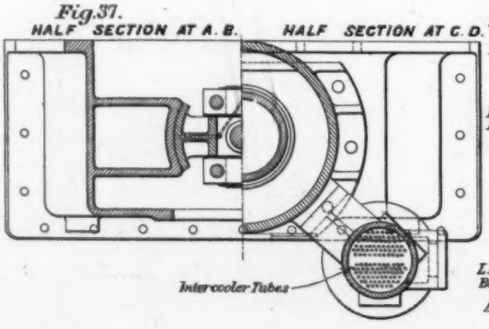
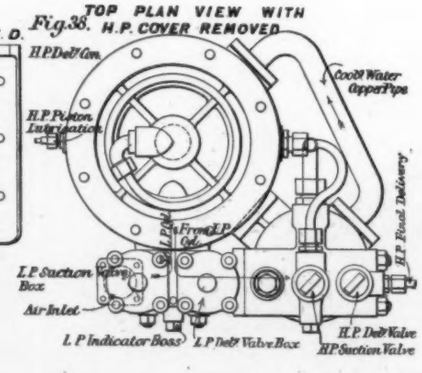


Fig. 38. TOP PLAN VIEW WITH H.P. COVER REMOVED



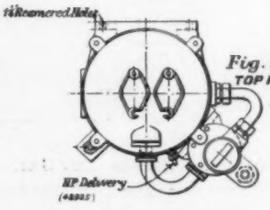


Fig. 50. TOP PLAN VIEW

Fig. 51. PLAN OF AUX[ILIARY] AND I.P. CYL.

SEL NTERNAL-COMBUSTION ENGINE INSTALLATIONS.

EAVELL CO., LIMITED, ENGINEERS, IPSWICH.

(See Page 480.)

Fig. 40.

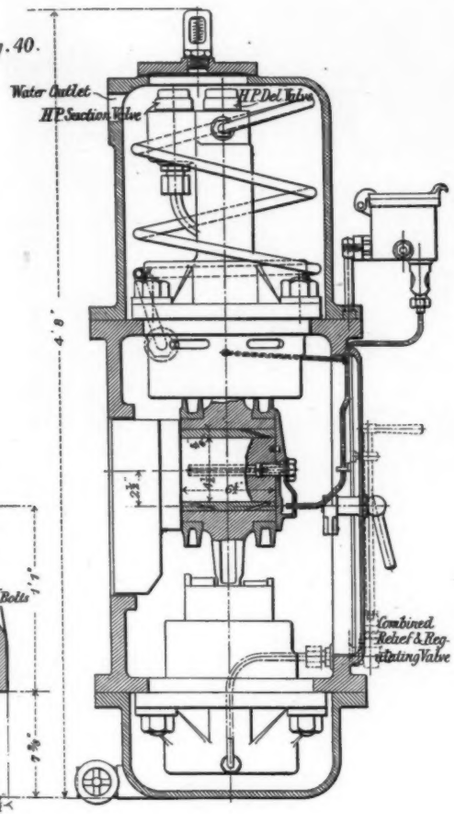
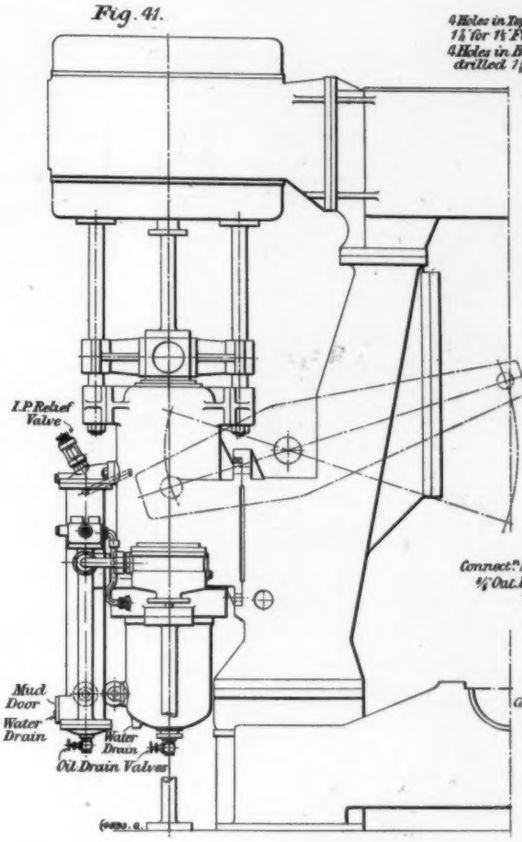


Fig. 41.



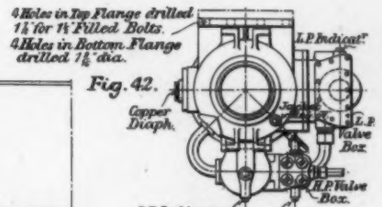
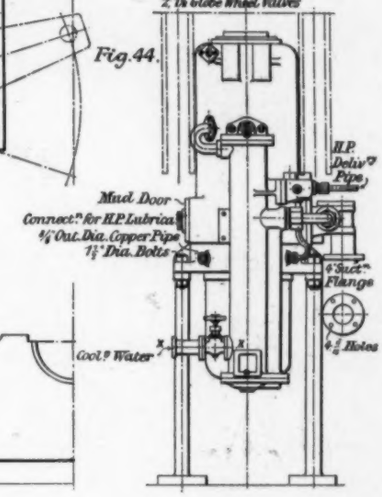

4 Holes in Top Flange drilled 1⅛ for 1⅛ Fitted Bolts.
4 Holes in Bottom Flange drilled 1⅛" dia.
I.P. Indicat.r
Copper Diaph.
L.P. Valve Box
H.P. Valve Box.
I.P. Indicator
H.P. Indicator

Fig. 42.

SEC. AT X.X.

Fig. 43.

Fig. 44.



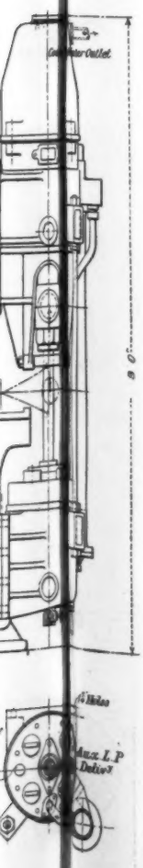


Fig. 52.

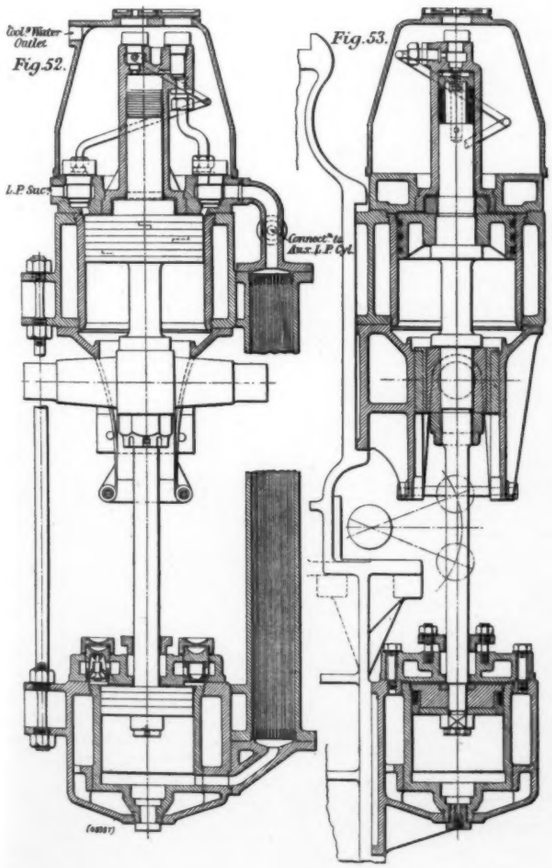


Fig. 53.

Fig. 45.

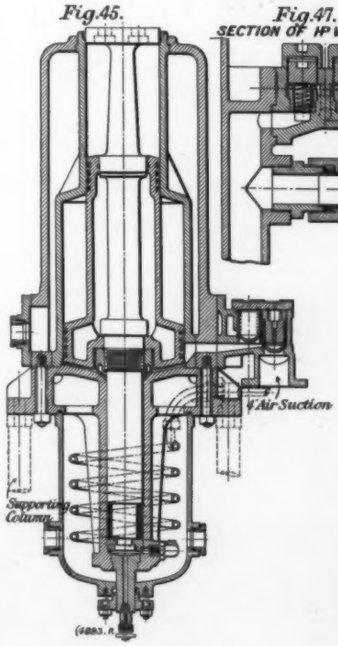


Fig. 47.

SECTION OF H.P. VALVE BOX

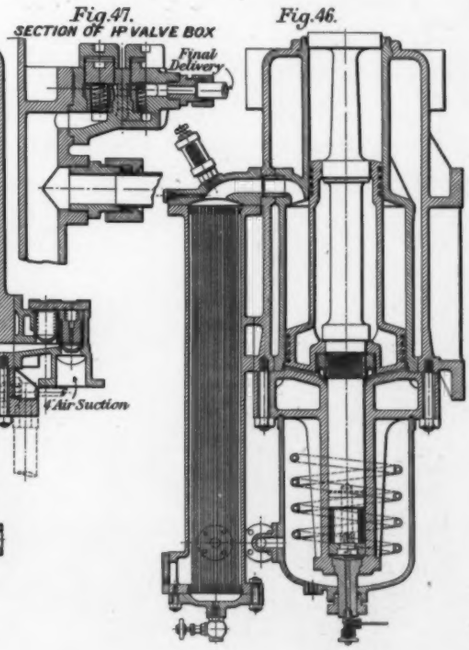


Fig. 46.

HIGH-PRESSURE AIR-COMPRESSOR.

CONSTRUCTED BY THE GENERAL ENGINE AND BOILER COMPANY, LIMITED, NEW CROSS, LONDON.

(*For Description, see Page* 480.)

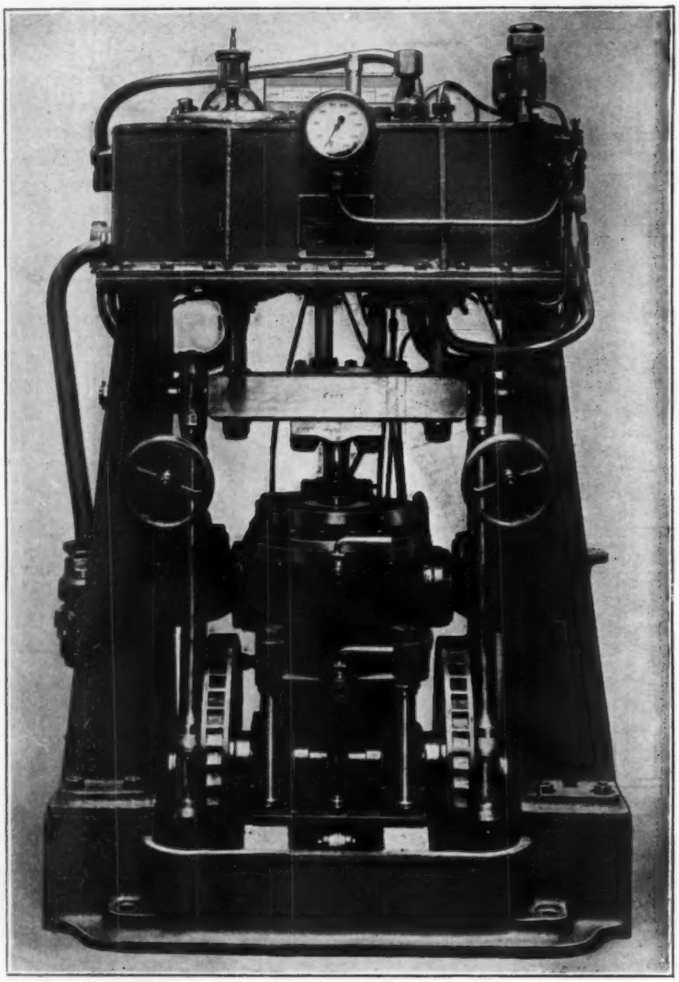
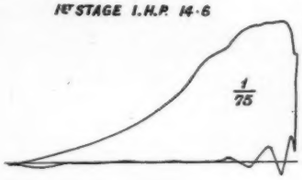


FIG. 55.

Fig. 56.

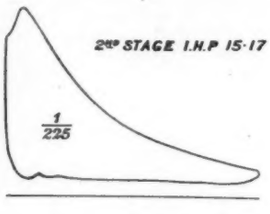
GAUGE PRESS. AFTER COOLING			
STAGE 1	STAGE 2	STAGE 3	STAGE 4
46·5	260	925	3000

1ST STAGE I.H.P. 14·6



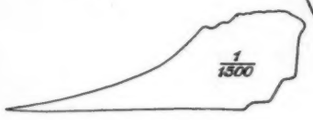
GAUGE PRESS. AFTER COOLING			
STAGE 1	STAGE 2	STAGE 3	STAGE 4
46·5	265	900	3000

2ND STAGE I.H.P. 15·17



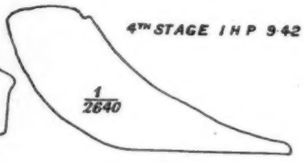
GAUGE PRESS. AFTER COOLING			
STAGE 1	STAGE 2	STAGE 3	STAGE 4
46·5	265	900	3000

3RD STAGE I.H.P. 11·41



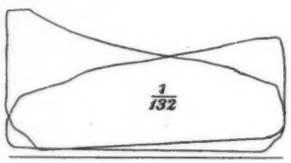
GAUGE PRESS. AFTER COOLING			
STAGE 1	STAGE 2	STAGE 3	STAGE 4
46	260	900	3000

4TH STAGE I H P 9·42



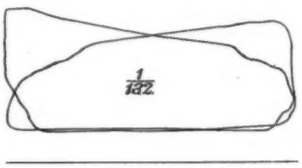
STEAM CYLINDER I.H.P. 73·5

Air Pressure 3000 Lbs. per Sq. In.
Steam " 165 " " " "
Exhaust " 0 " " " "



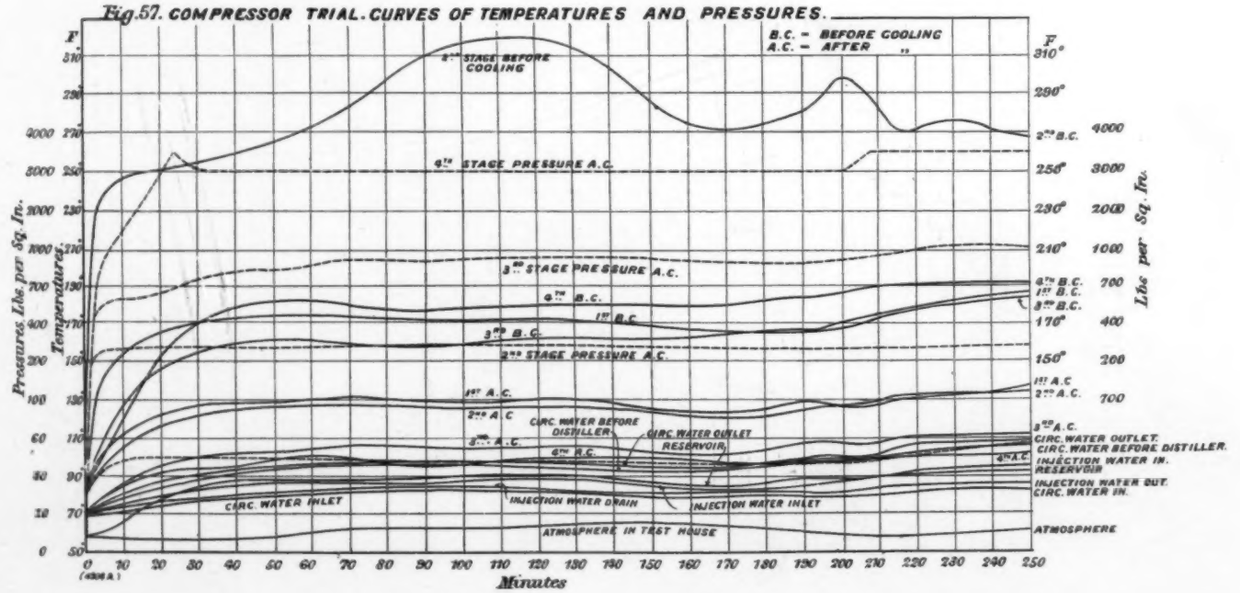
STEAM CYLINDER I.H.P 76

Air Pressure 3000 Lbs. per Sq. In.
Steam " 150 " " " "
Exhaust " 25 " " " "



All Diagrams 340 Rev's per Min.

Fig. 57. COMPRESSOR TRIAL. CURVES OF TEMPERATURES AND PRESSURES.



(*To face page* 481.)

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Turner and Henderson, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
CANADA, Toronto, Ont.: Wm. Dawson & Sons, Manning Chambers. Montreal: Sells, Limited, 302, Shaugnessy Building, McGill-street.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Subscriptions and Advertisements, Librairie B. Tignol, 53bis, Quai des Grands-Augustins, Paris. Also for Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co. Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan, and any post-office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland, and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elisabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Longstreet.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston; Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. Chicago: H. V. Holmes, 967-968, Monadnock Block.
For Advertisements, J. S. Allan, 506, Stratford Avenue, Bridgeport, Conn., U.S.A.

ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

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NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 17, at 6 p.m., at the Institution of Civil Engineers, Great George Street, Westminster. Paper on "Report of the Hardness Tests Research Committee.

THE ASSOCIATION OF MINING ELECTRICAL ENGINEERS: NOTTS. AND DERBYSHIRE BRANCH.—Saturday, November 18, at the University College, Nottingham, at 3.30 p.m. Paper for discussion:—"Some Electrical Troubles and their Remedies," by Mr. Thomas Anderson.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 21, at 5.30 p.m. Paper to be submitted for discussion:—"Keadby Bridge," by Mr. James Benjamin Ball, M.Inst.C.E.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday evening, November 21, at 8 o'clock, at the House of the Royal Society of Arts, John Street, Adelphi, W.C. The following paper will be read:—"The Pyrogenesis of Hydrocarbons," by Mr. E. L. Lomax, M.Sc., F.C.S., Dr. A. E. Dunstan, D.Sc., F.C.S., and Dr. F. B. Thole, D.Sc., F.C.S. The chair will be taken by the President, Professor John Cadman, C.M.G., D.Sc., M.Inst.C.E.

THE ROYAL SOCIETY OF ARTS.—Wednesday afternoon, November 22, at 4.30 p.m. A paper on "The Economic Development of Russia and Britain's Share Therein" will be read by Mr. Leslie Urquhart. The Right Hon. Lord Carnock, G.C.B., G.C.M.G., G.C.V.O., K.C.I.E., British Ambassador in Russia from 1906-10, will preside.

THE CONCRETE INSTITUTE.—Thursday, November 23, at 5.30 p.m., at Denison House, 296, Vauxhall Bridge Road, Westminster, S.W., when Mr. F. E. Wentworth-Sheilds, M.Inst.C.E., &c., will deliver his first Presidential Address.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 23, at 8 p.m. "The Parallel Operation of Electric Power Stations," by Mr. J. S. Peck, Member.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, November 24, at 7.30 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Newcastle-on-Tyne. The discussion will be resumed on "Works Organisation," by Mr. A. D. C. Parsons, B.A., Member. Mr. Edwin L. Orde, Vice-President, Mr. G. H. Tweddell, Member.

THE PHYSICAL SOCIETY OF LONDON.—Friday, November 24, at 5 p.m., at the Imperial College of Science, Imperial Institute Road, South Kensington, S.W. Agenda: (1) "The Measurement of the Thomson Effect in Wires," by Mr. H. R. Nettleton, M.Sc. (2) "The Thermo-Electric Properties of Fused Metals," by Mr. C. R. Darling, A.R.C.S., F.I.C., and Mr. A. W. Grace.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, NOVEMBER 17, 1916.

DILUTION OF LABOUR IN SHIPBUILDING AND ENGINEERING WORKS.

AMONG the staple industries of the country few, if any, absorb more of our man-power than shipbuilding and marine engineering. But the needs of the Navy now, and those of the oversea transport even at present, and still more so after the war, make it imperative that work shall be maintained to the maximum extent in these trades. There is little need to enforce that view. And yet it is even more imperative that the army should not only be kept up to its present strength in the face of losses, but that it should be augmented to the greatest possible extent. Every fit man who can be spared from this, as well as from all industries, must therefore be released for service with the Colours, while production essential to the prosecution of the war must be maintained at full pressure. It is only by the extension of the principles of dilution of labour that this result can be attained. Shipbuilding work does not lend itself easily to such dilution by the introduction of female workers, as will presently be shown; but the great measure of success achieved in this direction owing to the patriotic action of both employers and employed forms an illuminating lesson to others, and particularly to Government departments, where the process of dilution is comparatively a simple matter. A review of the situation is, from this point of view, most desirable: moreover, it points the way to firms who have not yet been able to carry out dilution to the fullest possible extent.

The success which has attended the introduction of female labour in the various operations involved in shell-making and filling, and in the manipulation of automatic and semi-automatic machinery for the production of gun and rifle parts, &c., now fairly well known and appreciated, is easily understood. The extent to which female labour has been utilised in shipbuilding yards and marine engineering shops is not so generally known, but is even more gratifying because of the difficulties due to the variety, arduous character, and varied nature of the work. The application of the principles of the dilution scheme, whereby unskilled and semi-skilled men are allowed to do work previously done by skilled tradesmen, has worked well in practice, and many skilled workers have thereby become available for more important duties. Dilution of labour in the form of transferring a temporary surplus of skilled workmen of one trade to relieve a shortage in another trade has been of considerable service in meeting sudden demands on particular trades. Joiners have been transferred to carpenters' and sheet-iron work; plumbers to copper pipe and steel pipe fitting; riveters to water-testing; and ship smiths to angle smiths' work during periods of exceptional pressure. Lines of demarcation have been waived in order that jobs might be transferred from one trade to a more adequately manned trade in order to expedite production. The system is, however, at best only a temporary expedient, and is not too favourably viewed by the workmen.

The most important advantages of the dilution scheme, alike in present achievement and in promise of development, are undoubtedly due to the introduction of female labour in place of unskilled, semi-skilled and even skilled men in machine shops. The conditions of work in machine shops—the large number of automatic and semi-automatic machines used; the comparatively simple nature of the operations involved in the production of many small jobs; well-lighted and ventilated shops where work is done in more or less self-contained groups, are almost ideal for the introduction of female labour. The first applications of this principle of dilution in the shipbuilding industry have therefore been made in engine shops, largely in the direction of substituting women for the men previously employed on turning and drilling operations and in attending a variety of machines. They have proved so successful that the principle has been considerably extended. At the present time large numbers of women are employed on lathe work—rough turning and finishing—at shaping and milling machines, drilling machines, bolt-making machines, &c., the machines and tools being set in most cases by skilled workmen attending a number of machines. Condenser tubes are cut, straightened, screwed and fixed in position; turbine blading is cut and prepared for fixing in rotors and casings; white metal linings for bushes are hammered, scraped and finished; and in at least one shop water-tube boilers are erected almost entirely by female labour—even to the working of the overhead cranes for lifting the pieces into position.

The further extension of the work which can be successfully accomplished by female labour depends greatly upon the class of work undertaken by the firm, but filing and chipping, the fixing of turbine blading, assembling and erecting small jobs such as valves, &c. (particularly brass work), bending of small pipes and fixing flanges, and light brazing work are all within the powers of suitably trained and supervised women. The successful employment of women will to a very large extent depend in all cases on the selection of suitable and special'y trained overseers or forewomen who can be trusted to deal firmly, yet sympathetically, with the employees, many of whom will be under workshop discipline for the first time. The ranks of retired schoolmistresses would seem to offer a likely recruiting ground for the selection of forewomen.

In shipyards operations are conducted in a number of shops or sheds as well as on the building berth, the character of the machinery used being entirely different from that used in an engine shop. It is, generally speaking, of a more substantial make, does a larger variety of jobs per machine, and rarely is employed for any length of time on one class of work. Moreover, there is very little automatic machinery in use in the shipyard. The conditions of work, as between engine shop and shipyard, are also very different, for, whereas in the engineer's shop the work involves a very high percentage of extremely accurate machine operations, that of the shipyard involves an almost equally high percentage of manual labour—much of which is conducted in the open and often under very adverse conditions as to weather and safety. These points must be given due weight to in applying the principle of dilution by the further utilisation of female labour in shipyard work. It would naturally follow, then, that a start would be made by employing

women on suitable work under cover, gradually extending their employment until they are engaged on the building and finishing operations. Something has already been done on these lines, but much more can and must be done now.

At the present time women are employed on the following shipyard operations:—Cleaning out machine shops, stores and offices; attending light drilling machines; red-leading and rough painting, and labouring for joiners and carpenters—all with satisfactory results. There is no reason to think that they could not be employed with equally satisfactory results on much more work. They could check sizes of plates and angles on delivery into the yard; where adequate facilities are available for the handling of raw material there should be no difficulty in measuring the dimensions of raw material and comparing these with the order. Rivet, tool and general storekeeping is work which could easily be undertaken by women, especially on the serving and accountancy sides, under the supervision of an expert storekeeper. In the plater's sheds there are a number of machines and operations which could well be undertaken, viz., attending plate-planing machines, high-speed drilling machines, countersinking machines, and operating large hydraulic or electric machines and cranes; the making of light wooden templates and marking plates and angles from templates, screwing up material ready for riveting on the skids, and even light hydraulic riveting. Among general operations which could be undertaken are the making of brass clips for electric wiring, soldering operations, working of engraving machines, weighing material, tapping and screwing operations, finishing smithwork such as stanchions and mast mountings, cutting and welding by the oxy-acetylene process, packing of watertight work before riveting, and operating moulding, sandpapering, mortice and tenon machines in the joiners' shop. Time-keeping and the issue of checks could be done by women. Labouring work of the lighter kind, such as for joiner's, sawmill, carpenter's, plumber's, and electrician's work is easy of accomplishment by female labour.

The problem of the employment of women on board ship during building operations presents some difficulties, among which the ensurance of efficient supervision and the provision of suitable staging during the earlier stages of construction are of importance. Neither difficulty is, however, insuperable, and women could then be employed with advantage in screwing up decks, shell plates, &c., packing watertight work, running electric cables, drilling and reaming operations involving the use of electric or light pneumatic machines, red-leading, and cleaning up the ship. The operation of hoists, derricks, travelling cranes and winches is another field for the employment of female labour, while their employment as rivet heaters would enable a large number of lads to commence riveting. This list could, of course, be extended so as to cover many minor operations suitable for women, but these vary with local practice and may not be universally applicable, but sufficient has been said to show the possibilities for development.

It must be borne in mind that while the substitution of women for unskilled or semi-skilled men who are not eligible for the army may at first sight seem a dubious benefit, yet the displaced men, being used to the training and discipline of work, should be available for replacing physically fit or, in some cases, skilled men in their own or another trade. In this way several moves may have to be made in order to employ the services of a highly skilled man to better advantage. But the great consideration, after all, is that not until every fit man who can be spared is in the army and every skilled tradesman is employed on work of urgent national importance will the man-power of the nation be properly organised for the gigantic struggle which still confronts the Empire and our Allies.

THE COST OF POWER.

The steady rise in the price of coal has led manufacturers to view with some alarm the probable cost of their power supplies in the future. Some interesting data as to what it has been in the past are to be found in the report just made by Mr. C. E. Stromeyer, the Chief Engineer to the Manchester Steam Users' Association. Mr. Stromeyer observes that during the early years of the Association it was the practice to collect and publish reports on the performance of engines owned by members, but that this custom afterwards lapsed, and he has, it appears, found some difficulty in reviving it. Nevertheless he has been able to give some interesting figures, which may perhaps be taken as fairly representative of the efficiency of the engines now commonly used in mills. If anything, the figures are likely to put a favourable face on affairs, since the proprietors of really bad engines are undoubtedly much less willing to supply data, even if these are to be published with no indication of origin, than those who have up-to-date plant and who are naturally somewhat proud of the fact.

Mr. Stromeyer's figures show that in cotton mills having engines designed to work with steam at 100 lb. gauge pressure the coal consumption, averaged throughout the year, amounts to about 3 lb. per indicated horse-power hour. In the case of high-pressure compound engines the corresponding figure is about 2.15 lb., whilst with triple expansion engines it falls to 1.65 lb. of coal per indicated horse-power hour. The loss due to banking fires during two-thirds of the year, for which the engines are idle, Mr. Stromeyer estimates at 0.3 lb. per indicated horse-power actually developed; even with this deduction the figures are, of course, higher than on reception trials, when all valves are tight and other sources of loss eliminated. Making allowance for this, the figures appear remarkably good, especially when compared with the results obtained in the trials of marine engines organised by the Institution of Mechanical Engineers.

Unless power plant is well maintained, the steam consumptions tend to rise with lapse of time. In the case of reciprocating engines valve leakage may increase seriously without being suspected; whilst in the early days of the steam turbines carelessness as to air leakage into the condenser often increased the consumption by 6 or 7 per cent.

Taking Mr. Stromeyer's estimate of 0.3 lb. per indicated horse-power hour as attributable to banked fires and other stand-by losses, the coal consumption in practice of a good triple expansion mill engine appears, as stated by him, to be about 1.33 lb. per indicated horse-power hour. It is of some interest to compare this with the best recorded results actually practicable. The 30,000 kw. turbine at the Interborough Station, New York, is reputed to convert into electric energy 25 per cent. of the heat supplied to it. This performance exceeds that of older-type gas engines and compares well even with that of the modern gas engine, the higher thermal efficiency of which is considerably discounted by its relatively low mechanical efficiency, which in the case of a steam turbine is of the order of 98¼ to 99 per cent. At one of the large power stations in the Newcastle district the boiler efficiency exceeds 80 per cent., as averaged over the year, so that apparently an overall efficiency from coal to electricity of about 20 per cent. is now practicable, corresponding perhaps to a coal consumption of less than 1 lb. per kilowatt-hour; equivalent, when allowance is made for power absorbed in auxiliaries to, say, 0.8 lb. per indicated horse-power hour.

Taking average results in present mill practice Mr. Stromeyer estimates that not more than 1 to 2 lb. per indicated horse-power is likely to be saved by modernising an old power plant. At pre-war prices the corresponding money saving would not amount to more than 1*l.* to 3*l.* per horse-power per annum. On the other hand, he observed that by providing ample boiler power a very great money saving could be effected owing to the possibility in such case of using lower class fuels. Mr. Stromeyer holds that our manufacturers have been spoilt in the past by the ample supplies of excellent coal which have been available for years at low prices. As works have grown, the boiler-house plant has accordingly not been increased *pari passu*. With good coal it was quite possible to get the additional power from the existing plant. As a consequence, there has been little demand for the lower-grade fuels, which have thus been wasted in enormous quantities in the past. Such coal can, however, be used to advantage provided the number of boilers is suitably increased, and provided also that this inferior coal can be delivered to the doors at a suitable price.

Some industries will naturally gravitate to countries where water power can be very cheaply obtained. Mr. Stromeyer states that in the hydro-electric power stations of Norway the cost may be as low as 35*s.* to 50*s.* per horse-power year for continuous service, whilst in a modern factory using coal even at the pre-war price of 12*s.* 6*d.* a ton the cost would be 6*l.* per horse-power year.

In the case of the Newcastle Electric Supply Company, Mr. Stromeyer states that an all-year load is furnished at 4*l.* 10*s.* per electric horse-power, but if an eight-hour day only be worked the charges are naturally higher, possibly as much as in the case of a first-class isolated plant.

In other industrial districts conditions are less favourable, as almost every corporation refuses to allow its ratepayers the benefit of a supply from a power company. The latter is, moreover, handicapped by the low limit of voltage which the Board of Trade has fixed for transmission lines. This body is also in the main responsible for the conditions which have led to the present multiplicity of supply systems with different voltages and periodicities, which greatly increases the difficulty of linking up adjacent areas. Probably this condition of affairs was to some extent purposely encouraged by the politicians, to whom the idea of large companies supplying wide areas was *anathema*. The production of cheap power from fuel carted to small independent generating stations is, Mr. Stromeyer says, impossible.

Apparently he expects a considerably greater development of the internal combustion engine in the future; the latter, however, suffers from a number of disabilities. It is, Mr. Stromeyer states, both less uniform in running and less reliable than the steam engine, but in medium and in small powers it is very much more economical. The maximum possible efficiency of a producer is, however, not greater than 75 per cent., whilst with boilers an efficiency of over 80 per cent. is regularly attained in certain stations, though no doubt the conditions are exceptional. The stand-by losses of the producer are, however, very low, and very little time is required to pass from no load to full load.

Mr. Stromeyer appears to look forward to the early introduction of the internal combustion turbine. The prospects of success in this direction, however, seem at present to be small. The difficulties connected with the high temperatures involved are perhaps not insuperable, but the fact remains that the internal combustion motor is essentially one in which the negative work is necessarily a large proportion of net. For reasons of cost it appears impracticable to adopt reciprocating compressors to feed the turbine, and no rotary compressor has so far even approached the limit of efficiency essential to success.

Where water powers are not available steam still provides the most economical and convenient method of developing large powers, and some engineers at any rate believe that no long time will elapse before as high overall thermal efficiencies will be realised with steam as are now obtained with gas engines.

TRADE PROPAGANDA IN RUSSIA.

Russia is one of the countries of vast potentialities where Germany was steadily capturing British trade, and it is very satisfactory to realise that our manufacturers have awakened to this fact. There is, however, much ignorance, and consequently much misunderstanding, as to the systems of trading in that country. It is consequently of importance that those who have studied the Russian commercial procedure should do all they can to rectify the errors. Mr. Wm. Hy. Beable, who has just returned from a very extensive tour in Russia, undertaken partly in order to investigate trading methods, addressed last night the Sales Managers' Association in London and gave valuable hints regarding commercial propaganda in that vast territory. He stated that Germany contributed roughly 60 per cent. and England 10 per cent. of the 100,000,000*l.* of imports into Russia per annum, but

recently the *Board of Trade Journal*, which gave the total imports from abroad in 1913 as 145,000,000*l.*, quoted Germany's proportion as 50 per cent. and that of the United Kingdom as 13 per cent., as compared with 35 per cent. and 19 per cent. respectively 10 years previously. Even the latter figures show that there is a great opportunity for British manufacturing firms in capturing the German trade. In our issue of January 14 last we published details of the imports into Russia from Germany of metals and machinery, in order to show the direction in which this movement should proceed.

Mr. Beable's contribution is valuable because of the suggestions he makes regarding the method of attack. He attaches the greatest importance to a knowledge of the Russian language, to catalogues and all correspondence being in this language, including Russian weights, measures and currency, and to goods being delivered to a Russian port instead of being consigned f.o.b. England. These are all conditions so essential that the ignoring of them in the recent past clearly establishes gross negligence. Another important point is that there should be complete sympathy with Russian aspirations. Their aim is to develop their own industries. This necessarily will take time, and in the interval general merchandise will be acceptable. A great opening exists for the manufacturers of factory machinery and equipment, in order that the internal industries may be established and developed. The Russians no doubt will welcome British branch manufacturing institutions, and on this point Mr. Beable makes an important recommendation in stating that as customs duty is charged on a basis of weight, the initial work, at least in Russia, should be confined to the production of heavy castings and forgings, while the smaller, intricate parts, involving a great amount of expert machine work, should be imported.

He successfully controverts the theory that the Russians seek for long credit. There has been a tendency lately to such long credit, due to the cultivation of the German method of banks financing manufacturers and local banks and discounting their bills on the London market. This latter procedure should be made impossible, as the small yield to the financier is at great cost to our manufacturers. It is his experience that the Russians do not seek for more than three or four months' credit. This is due to the facts that they have no cheque system, that the distances of transport are great, and that time is required in collecting money, even if exacted immediately upon the delivery of the goods. On the other hand, the Russian in the past has not readily transmitted the cash in payment of bills, waiting until it is collected. For this reason Mr. Beable suggests that where the resident agent cannot be trusted with the collection of moneys, a combination of our exporting firms should send a reliable man once or twice per annum to collect accounts personally.

An important problem is as to what type of agent should be appointed. There are bad as well as good Russian commercial houses, so that close investigation is necessary before making the appointment. The sending of catalogues, with agency terms, to any applicant is to be deprecated, as such promiscuous procedure may have its disadvantages. Nor is it desirable that agents should be appointed for the whole of Russia. The fact is rarely grasped that Russia is more than twice the size of Europe, and that European Russia alone is more than half the whole of Europe. In some cases, as, for instance, in the case of textile machinery, the field can be fairly well covered from Moscow, which is the great locality of the textile industry, and is the most important distributing centre. As a rule, as was pointed out by Mr. Beable, for anything like merchandise there should be agents at both Petrograd and Moscow, at Kharkov or Ekaterinoslav, at one of the Black Sea ports, at Rostov-on-Don, in the Lower Caucasus, at Klaterinburg and in Siberia. If the trade justifies it, Mr. Beable thinks it an excellent plan to get a bright young fellow trained for the purpose, with at least an elementary knowledge of Russian, and send him to Russia, with samples, prices, &c. It is comparatively inexpensive, and a suitable man will soon establish wide connections. Where agents are employed he thinks also that it is extremely desirable that a representative of the firm should go to Russia occasionally, get into touch with the customers, look after overdue accounts, and generally seek to get the best service from the agent. We are glad that he enforces the view that firms ought to rely on their own enterprise, seeking for Government help only in a subsidiary way. The British Consular service, he points out, is not organised to render any great assistance in the development of British trade, as it is based on certificates, the making of commercial reports and investigations being secondary. It requires great extension; its cost does not exceed 10,000*l.* per annum, and yet the prize is 70,000,000*l.* of German trade in Russia. Mr. Beable makes no reference to the proposal to form a Russo-British bank, corresponding to the Italian-British bank now being established. This, we think, is an indispensable auxiliary to any campaign for the recovery of that trade which Germany has been steadily winning from us during the last 40 years.

THE STABILITY OF GREAT BRITAIN.

A BESETTING sin, nationally and individually, is the taking of narrow views, or the failure to grasp the broad significance or influence of incidental occurrences. All capable of taking a broad view should, when possible, lift the vision of the people from their narrow outlook, and Dr. Dugald Clerk did useful service when, in his address last Wednesday, as chairman of the Royal Society of Arts, he dealt widely with the stability of Great Britain. The subject covers practically the whole field of thought and action. It raises the question of our financial solvency in the face of the immense and increasing burdens imposed upon us by the war. It embraces the entire scope of future trade relations, not only from the imperial but from the international standpoint. It concerns the efficiency of productive methods, and particularly the relation of employer to worker. It encompasses the whole field of applied and pure scientific knowledge, art and literature, in their relation to the well-being of the nation. So far as the financial condition was concerned, Dr. Clerk saw no room for anxiety. He established that our annual income per head of the population now averages 54*l.*, as compared with 32*l.* in the case of Germany, while our annual savings, which before the war were 350 millions sterling, increased in 1915 to 600 millions sterling, and will probably come up to 1,000 millions sterling in the current year. Our external investments are 4,000 millions sterling —four times those of Germany—and the utilisation of the profits from these in paying for war and other supplies from neutral countries without affecting exchange, and the maintenance inviolate of our foreign capital, apart altogether from the continuance of import and export trade, are important results of the work of our navy.

As regards future commercial relationships, Dr. Clerk very properly insisted on the view that the idea of a self-contained nation was unattainable if such a nation was to prosper. He elaborated the principles of foreign exchange, which are not sufficiently understood by the general public, pointing out that "what a nation required is not money but material things and services. All that the financial system does is to make possible an exchange of those goods and services within the country and in the external world." To give an example—the 32 millions sterling a year going to Canada is mostly used by the Canadian people for the purpose of buying goods from the United States. That country may in turn use the money so placed to its credit in London for the purchase of tea from India, silk from Japan, coffee from Brazil, French works of art, &c. Ultimately our credit to Canada is supplied by exports to those countries where British goods are needed. In other words, imports are as necessary as exports, the one paying for the other. It follows, however, that the country which can export most can import most. Consequently the prosperity of a nation, both collectively and individually, is dependent upon the volume and output of her trade and the securing of markets for their productions.

It follows, therefore, that prosperity depends on efficiency in manufacture, alike in the appliances available and in their utilisation. Labour thinks often that it does not get its adequate reward. There can be no doubt that the limitation of output is largely a result of the workers' suspicion that the employer or his representative will reduce total earnings, when he considers these too large, by lessening the piecework rate. The tendency should rather be to offer every inducement to the worker to earn the largest sums per week, provided the price of each article is a fair one, which can be borne by the selling prices available. This latter can the more effectively be achieved if the appliances are of the most efficient character. Dr. Clerk entered into a consideration of the census of production taken in 1907, showing that in manufactures the total earnings of industry per head per annum was 102*l.*, from which there had to be met, not only the wage of the worker, but the remuneration for capital, the accumulation of funds for the extension of works, and the development of new inventions or industries by experiment and research. If wages are to be increased, and if there is to be development in science and in its application to industry, the volume of output, and therefore its value, must be increased. In America the output per worker per annum is quite 1½ times what it is in this country; in Germany it is considerably less. Earnings are fairly proportionate in the respective countries to the output. An increase of the output in this country to the extent of 50 per cent. by greater utilisation of automatic machinery would produce a great improvement in our prosperity as a whole, without increasing the working hours, it would tend to raise earnings and increase purchasing power. Our future stability, therefore, will be greatly increased by greater sympathy between employer and employed, and a fuller realisation of their mutual obligations and their duty to themselves and to the State.

HARNESSING A VOLCANO TO A 15,000-HORSE-POWER ELECTRIC POWER-HOUSE.

By PROFESSOR LUIGGI, D.Sc., M.Inst.C.E.

THE idea of utilising volcanic heat to drive an important electric power-house of 15,000 h.p. might have been considered utopian in ordinary conditions. It has, however, become a reality—and a successful one—in these hard times, when the price of coal has reached in Italy the incredible figures of 8*l.* to 9*l.* a ton in the harbours and 9*l.* to 10*l.* in inland towns—plus the cost of carriage from the stations to the works!

The installation had this origin: As is well known, in Central Tuscany, near Volterra, there are numerous cracks in the ground, from which powerful jets of very hot steam spout high in the air with great violence and constancy, bringing up boric acid—which is very valuable—and other mineral substances of less importance. These powerful jets of superheated steam are called *Soffioni*—the "blowers"—and have been utilised for many years in the production of boric acid and borax, and occasionally for warming the houses in the near-by village of Larderello. The larger proportion of the steam, however, is lost, having no local application, and with it is lost its very valuable heat.

Prince Ginori-Conti, the intelligent and active president of the "Società Boracifera di Larderello," was the first, in 1903, to try to utilise this superheated steam for the production of motive power. At first he applied a strong jet to a small rotary motor, then to a very modest reciprocating steam engine connected to a dynamo, which generated sufficient current to light part of the borax works. In the meantime he tried to get a more ample supply of steam by boring holes in the ground, lined with iron pipes, driven down to the very source of the steam, which is under a hard stratum of rock about 300 to 500 ft. below the surface. These bore-holes vary from 12 to 20 in. in diameter, and give forth steam with a pressure from 2 to 3, and exceptionally up to 5, atmospheres, and at temperatures varying from 150 deg. C. to 190 deg. C. For several years these jets have not diminished in their capacity, nor does a new boring seem to interfere with the preceding ones, provided the distance from one to another is not less than 50 ft.

Experiments made very accurately demonstrate that each bore can provide steam at a temperature

of at least 150 deg. C., and at the rate from 15,000 to 25,000 kg. per hour, that is, practically, from about 1,000 to 2,000 theoretical horse-power per hour. Thus near Larderello there is the possibility of developing motive power to the extent of thousands and thousands of horse-power. Encouraged by these results, Prince Ginori-Conti, in 1906, applied the steam to an ordinary steam engine of about 40 h.p. The experience of several years has shown that this arrangement works well so far as the mechanical power of the steam is concerned, but that the borax salts and the gases mixed with the steam—especially sulphuretted hydrogen and traces of sulphuric acid—have a corrosive action on the iron parts of the engine and are the cause of frequent repairs.

This difficulty was avoided by applying the superheated steam not directly in the engine, but to a boiler; that is, by applying it instead of fuel to an ordinary multitubular boiler, in which steam was produced at a pressure of 2 atmospheres, then passed through a superheater, and afterwards used for driving a 300-h.p. condensing steam turbine, directly connected with a tri-phase electric generator, which supplies the works and the villages around Larderello. This installation had been at work quite successfully for several months when the war broke out. Then, coal becoming very scarce, and prices rising up to prohibitive limits, the possibility of using on a large scale this natural steam became very important.

Prince Ginori-Conti considered it his duty to carry out this trial on a large scale, availing himself of his long and successful experiments. Acting on the advice of the Tosi Works, of Legnano—specialists in steam turbines and alternating electric generators—he ordered three groups of condensing turbo-electric engines, each of 3,000 kw., working with superheated steam at 1½ atmospheres, generated in specially-constructed multitubular boilers, the latter arranged vertically and with aluminium tubes, both for better utilisation of the heat and better resistance to the corrosive action of the natural steam from the *soffioni*. This steam, it is worth while to repeat, is used instead of combustible; it loses part of its heat in the boiler, reducing its temperature from 180 deg. C. to about 120 deg. C., and is then utilised for the borax industries.

The steam thus generated in the boilers and used for the turbines is ordinary water steam, which on its way to the turbine passes along aluminium pipes heated outside by a current of superheated natural steam, at 180 deg. C., and thus gets in its turn superheated to about 150 deg. C. After passing through the turbine this steam is discharged into a surface condenser, the circulating water of which is in its turn cooled in an ordinary cooling tower. The condensed steam from the turbines is, of course, pumped back into the boilers, and thus no natural steam ever comes in contact with the turbine; by this arrangement corrosion is completely avoided. This was the real difficulty to be overcome.

The tri-phase electric current is generated at 4,500 volts and 50 periods per second, raised up through an oil transformer to 36,000 volts, and sent along aerial conductors to Florence, Leghorn, Volterra, Grosseto and many smaller towns of Tuscany, to be principally used as motive power for munition works during daytime and partly for lighting purposes at night.

One of the 3,000-kw. units has been at work since January, 1916, the second since April, and the third has just been started. So far, the first two groups have worked quite successfully and have been a great boon to the industries of Tuscany, greatly crippled by the scarcity and high price of coal. This very successful harnessing of volcanic heat to an electric power-house can be increased practically to hundreds of thousands of horse-power, as the region of the *soffioni* extends for many square miles around Larderello.

Also in the "Campi Flegrei," near Naples, the ground in some parts and at depths of about 100 ft. being almost red-hot, some similar utilisation of volcanic heat is already being contemplated. The Larderello power-house is, however, the first, and a very important and successful example of what has been done with volcanic heat in Italy. The results are well worthy of careful consideration, and Prince Ginori-Conti, who has financed the undertaking and steadily brought his experiments to a brilliant result, deserves great praise.

NOTES.

Electrolytic Spongy Zinc for Cyanide Baths.

Experimenters with galvanic baths generally complain that their solutions yield spongy, instead of firm, crystalline metal deposits. This is a nuisance, especially in quantitative analysis, and it might be thought that the production of an entirely spongy precipitate would be easy. When attempting to make a true sponge of zinc, however, Messrs. H. J. Morgan and O. C. Ralston, of the Bureau of Mines, experienced considerable difficulty. They wanted (New York meeting of the American Electrochemical Society, September 28, 1916) to prepare spongy zinc as a substitute for the zinc dust or zinc shavings required for precipitating gold and silver from cyanide baths. In 1913 the United States produced only 423 tons of zinc dust, whilst 2,200 tons were imported, principally from Germany and Belgium. When the war broke out, and prices went up, Morgan attempted to atomise zinc by passing air jets through the fused metal; the resulting dust formed small pellets, which were not efficient as reducing agents, however. Yet the Anaconda Works are said to atomise some 10 or 15 tons of zinc in this way daily and to use the dust for the neutralisation of their zinc sulphate baths, by preference to spongy zinc, which clogs up their Shriver filter presses. The efficiency of zinc dust as a precipitant is estimated after Sharwood, each milligramme of silver precipitated being considered equivalent to 0.1 per cent. efficiency. When Morgan and Ralston tried to make various electrolytic zinc deposits very spongy, they were not very successful. They added copper and arsenic to the sulphate to favour the spongy character; but these elements went into the silver, where neither is desirable, the arsenic giving off poisonous fumes. The addition of iron salts diminished the electric current efficiency. When zinc sulphate was fed with zinc oxide so as to keep slightly acid, and the bath was, further, maintained fairly hot, a good deal of sponge was obtained, and this sponge could be dried without oxidising much. Similarly treated baths of zinc chloride gave more sponge, but the zinc oxidised strongly during drying. The best results were obtained with sodium zincate, prepared by dissolving zinc or zinc oxide in caustic soda. The precipitation efficiency then rose to 75 per cent., but the current consumption was high, 3 kw.-hours per pound of spongy zinc. Zinc anodes may be used in the bath, and it may be possible to utilise roasted ores treated with caustic soda directly; but the caustic, of course, absorbs carbon dioxide from the air. Lead anodes may also be used: the lead is re-precipitated with the zinc, however, and impairs the efficiency of the spongy metal. The kathodes are discs of iron, half dipping into the bath, very slowly rotated about their horizontal axes.

The Fetesti-Cernavoda Danube Bridge.

The railway bridge of Cernavoda, near which fighting has recently taken place, carries the trains from Bucharest almost due east across the many arms and marshes of the Danube on their way across the Dobrudja to the port of Constanza, on the Black Sea. The bridge system consists of two main bridges over the chief arms of the Danube and a series of viaducts and embankments crossing the marshy ground between the left eastern arm, known as the Borcea, and the right eastern, wider arm, the Danube proper. With its total length of 11 miles, this railway bridge is one of the longest built, and though it does not perhaps rank with the grandest structures, it imposed exceptional difficulties on its builders. Below Silistria the Danube, already 1½ miles in width, curves to the north and divides, forming a swampy, frequently inundated belt, up to 20 miles in width, known as the Balta. This Balta extends nearly 100 miles to the north as far as Galatz, where the reunited Danube turns sharply to the east, soon to divide into the many arms winding through the dismal swamps of the vast delta. The railway bridge crosses the Danube at the point where the river is nearest to the Black Sea, the distance being about 40 miles. The railway from Cernavoda to Constanza (the Küstendje of the Turks) was the first built in Turkey, and runs near the ancient wall of Trajan, who conquered and colonised Dacia (106 A.D.), A bridge across the Danube was not seriously contemplated until the war of 1878 and the Berlin Congress had given the Dobrudja to Rumania. There were many difficulties to be overcome. The river beds and sands were continuously changing; the depth of the main arms, 14 m., was frequently raised to 21 m., and the whole district flooded over a width of 20 miles; the current and ice drifts are very strong, the winds terrific; the temperature may rise to 40 deg. C. and sink to − 30 deg. C. (104 deg. F. to − 22 deg. F.), and skilled labour was hardly to be obtained on the spot. To reduce delay the work was entrusted to three firms—Messrs. Schneider and Co., of Creusot, built the Borcea bridge over the Fetesti arm of the river; Messrs. Cockerill, the viaducts, &c., across the Balta; and the Compagnie de Fives-Lille, the Cernavoda bridge. The construction occupied the years 1891 to 1896. The Borcea bridge was illustrated in Engineering of October 21, 1898, in connection with a series of articles on Messrs. Schneider's works. The bridge, 418 m. (1,372 ft.) long, without approaches, is divided into three bays; the girders rise above the piers to a height of 33 m. and are inclined to one another, the width apart being 9 m. at the base and 2.6 m. at the top of the cantilever towers. The Cernavoda bridge of the Compagnie de Fives-Lille leaves, like the other bridge, a clear height of 30 m. (100 ft.) above mean water level, in accordance with the demands of the European Danube Commission. The total length of 750 m. (2,460 ft.) is divided into five bays, one of 190 m. and four of 140 m.; they rest on four piers and two abutments (brick and cement). The piers are founded on caissons, of 300 sq. m. area, sunk under compressed air to a depth of 30 or 32 m., as on the Borcea branch; the abutment on the left bank is upon a rocky support. The piers are strengthened by powerful ice-breakers of granite on the up-stream side. The two intermediate bays are constructed on the cantilever system, which was also adopted on the other bridge, and the semi-parabolic girders of 90 m. span are inclined to one another, deviating by 10 per cent. from the vertical. The superstructure is built of mild steel of a breaking strength ranging from 42 to 48 kg. per square millimetre (27 to 30 tons per square inch), and a minimum elongation of 22 per cent. The design allowed for a wind pressure on the bridge and passing train of 180 kg. per square metre (36.9 lb. per square foot), or 270 kg. (55 lb.) on the bridge alone. The weight of the metal structure was about 6,500 tons, and 50,000 cub. m. of brickwork were laid down, the cost amounting to 10,000,000 francs.

The Optical Society.—At a recent meeting of the Optical Society the election to honorary membership took place of Sir Frank W. Dyson, M.A., Astronomer Royal of England; Mr. Ralph A. Sampson, M.A., Astronomer Royal for Scotland; and Mr. Henry C. Plummer, M.A., Royal Astronomer for Ireland.

Some Errors in Steam Tables: Erratum.—By an error in transcription the formula for the specific heat of superheated steam given on page 233 of our issue of September 8, 1916, was reproduced as

$$C_p = \frac{777.8}{144} \cdot \left[\frac{d\,V}{d\,T}\right]_p \left[\frac{d\,P}{d\,T}\right] \phi.$$

It should read

$$C_p = \frac{144}{777.8} \cdot T \left[\frac{d\,V}{d\,T}\right]_p \left[\frac{d\,P}{d\,T}\right] \phi.$$

The correct expression was, of course, that used in testing the tables.

The Manchester Association of Engineers.—At a meeting of the Manchester Association of Engineers on Saturday last, the 11th inst., an interesting lecture was delivered by Mr. A. A. Barnes on "The Nile and the Utilisation of its Waters." Mr. Barnes indicated the outlines of the broad scheme whereby the waters of the river Nile are being controlled, by means of engineering works, for the purpose of irrigating Egypt and the Soudan. He dealt with the questions of the origin and regime of the annual flood, the works necessary to protect Egypt from inundation, and the storage works for retaining a reserve of water to meet the demand of the crops in the summer months. The lecture was supplemented by an interesting selection of lantern illustrations which had been obtained by the author personally, during his recent travels in Egypt.

REFRACTORY MATERIALS.

(Concluded from page 466.)

We conclude our notice of the general discussion on "Refractory Materials" by the Faraday Society on November 8.

Mr. Ezer Griffiths, M.Sc., of the National Physical Laboratory, contributed a paper on "The Thermal Conductivity of Materials employed in Furnace Construction." He gave an example of the importance of good lagging in his introduction. A muffle furnace heated by a Méker gas burner reached 1,300 or 1,400 deg. C. in 4 hours; when the outer surface had been covered with a 2 in. layer of magnesia-asbestos, that temperature was attained in less than two hours. As regards furnace construction, he said, one had to distinguish between (1) highly-refractory materials of great mechanical strength and chemical resistivity, and (2) materials wanted as backing to the refractory lining; these latter materials should have low thermal conductivity. In determining the conductivity, which varied greatly with the temperature, comparison should be made at various temperatures and, if possible, with specimens of the size in which they had been manufactured. Reviewing the literature on the subject, he referred first to Wologdin, who found that silica bricks burnt at 1,300 deg. C. had a conductivity 50 per cent. greater than those burnt at 1,050 deg. C.; that there was an increase in thermal conductivity with rising temperature for all materials excepting chromite, which seemed to have a constant conductivity; that the conductivities of carborundum (87 per cent. of SiC, 12 of SiO_2) and of graphite bricks (48 per cent. of C, 30 of SiO_2) was four or six times greater than that of firebricks. Experimenting on similar lines, Dougill, Hodsman and Cobb* had observed that the conductivity of magnesia decreased at higher temperatures, contrary to other observations. Boyd Dudley (American Electrochemical Society, volume xxvii, 1915) had built up a wall of bricks, 9 in. by 4½ in., heated it on one side, and drilled holes into the bricks, to insert thermo-couples, at right angles to the hot surface. This was a mistake; for Nusselt† had shown that when the wires were parallel or perpendicular to the isothermal planes, the temperatures might differ owing to conduction, by 40 deg. C. with a brick at 100 deg. C. Clement and Egy (University of Illinois, 1909) had applied the specimens in the form of hollow cylinders with longitudinal holes for the thermo-couples; that method was sound, but the specimens had to have the special form (cylindrical), and the radial distances were uncertain.

In his own experiments Mr. Griffiths placed the specimen of manufactured size in a tray filled with molten tin or pressed it, for working at temperatures above 450 deg. C., against a hot plate of iron. The wires of the thermo-couples were each sheathed with silica, and the whole couple again sheathed in with a silica tube of 5 mm. diameter; such a couple could be bent at right angles with the wires *in situ*, the bending being convenient when moving the couple in an arc over the slab. The flow calorimeter was provided with a guard ring, and this ring was separated from the calorimeter by a gap of 1 mm., stopped with plates of mica set edgeways; such a gap would, Mr. Griffiths thought, have made the Dougill apparatus more perfect. To obtain concordant results the experiments with thick samples of low thermal conductivity should be continued for days. The first experiments were made with diatomaceous bricks, diatoms being the silica shields or skeletons, probably of plant organisms, produced by the chlorophyll reacting with soluble inorganic salts. The heat-insulating property was largely due, apparently, to the minute air cells enclosed by the silica walls. The earth in question contained 92 per cent. SiO_2, besides oxides of iron, aluminium, calcium and of the alkali metals. The powdered material was mixed with a little clay, moulded, and fired at 900 deg. C.; the resulting porous bricks had a density of 0.64; the bricks had fair compressive strength, but were friable and would not stand abrasion. The thermal conductivity was found to vary between 0.000310 and 0.000461 c.g.s. units (gram-calories per second per cubic centimetre per deg. C.) between 105 and 502 deg. C., the maximum hot-face temperature being 939 deg. C. Still higher values were obtained with other specimens; when the material was deliberately ground, so as to destroy the structure, however, the insulating power was no greater than that of silicia sand. Slag wool, the second material tested, was prepared by blowing steam through molten blast-furnace slag; it was essentially a calcium silicate (silica 43, lime 48 per cent.) of density 0.24. Made up into compact mats with galvanised wire meshing over each face (interconnected by wires passing through the mat), the mat proved an excellent insulator, which should not be heated for long periods above 750 deg., however; the conductivity ranged from about 0.0002 to 0.000342 for mean temperatures (means between hot and cold face) of from 194 to 476 deg. C. As with the diatoms, the curve conductivity/temperature was practically a straight line. The white magnesia (the third material so far tested), as used for steam-pipe covering, was a basic carbonate prepared with about 15 per cent. of asbestos fibre as binding material; it had a low conductivity of 0.00015 at temperatures up to 350 deg. C., but underwent decomposition (liberating CO_2) at higher temperature and fell to a powder; in this state its thermal conductivity was by 100 per cent. higher. Worked into a pulp with water this white magnesia could readily be applied to irregular surfaces.

Professor W. G. Fearnsides, of Sheffield, speaking on "The Application of Petrographic Methods to the Study of Refractory Materials," gave scientific men and manufacturers a homely lecture and admonished them to pay more attention to the experienced foreman. Though there was a woeful lack of scientific data to help manufacturers beginning or starting on a new line, the foremen brickmakers and furnacemen who handled the materials, raw and manufactured, could impart a great deal of information, which needed to be collected and correlated. The scientific men should go through the works of manufacturers and users of the materials, listen to what experienced men said, spontaneously or under cross-examination, and translate that information into the international language of time and inversion-temperature, grain size and chemical composition which were the currency of the superior people who thought they knew. Makers and users should also work together as to the behaviour of the products under unusual stress, &c., with a scientific man to hold the balance. In its best development the art of making refractory materials was in advance of science, but the practice of the art by unskilled makers left much to be desired. Professor Fearnsides then passed to his own petrographic investigations, in which he had followed Sorby's method of studying the physical constitution of rocks and metals by rubbing down preparations to a condition of fair transparency, which meant to slices of a thickness of the order of 0.001 in. To study the relation of "plums to porridge" in a brick and the character of the binder involved greater difficulties in the technique than the preparation of rock slides or of polished surfaces of metals. In bricks of basic materials (magnesia, bauxite, zirconia, chromite), however, which were characterised by a high refractive index, enough was known to foretell approximately how the bricks would behave in the furnace. With new-made silica bricks, and especially with firebricks, the determination of composition and of the intrinsic structure was far less easy, because with slices of normal thinness the new-formed minerals were such tiny crystals that they interfered with one another and appeared as a felted mass. Yet the characteristic inversions of quartz to tridymite and cristobalite in silica bricks were comparatively easy to observe, and one could thus judge of the heat treatment a brick had received. [Quartz, tridymite and cristobalite are modifications or polymers of SiO_2, differing in crystal form, density, optical properties and in stability at different temperatures, and quartz has been called a geological thermometer.] More satisfactory from the point of view of demonstration specimens were micro-preparations cut from the bricks from the linings of large furnaces when those furnaces were dismantled; the careful selection and study of the more successful of those highly-metamorphised products might suggest to scientific workers a probable direction for the manufacturers' further advance.

Dr. A. B. Searle, of Sheffield, said that he had for years relied more on physical and microscopical methods than on chemical analysis of materials for firebrick manufacture, for reasons which he had fully explained in his book on "Refractory Materials, their Manufacture and Use." This book had been announced for publication three months ago, but had to be reset owing to a fire at the printer's. The petrological method described by Professor Fearnsides was by no means so new as might be supposed, though little had been published in this country; he had found it in extensive use in Germany in 1900, and had himself employed it since, especially the method of Wernicke, 1899, of ascertaining whether a silica rock would make good bricks; he examined the rock microscopically before and after treatment with stains. Co-ordination of research required some medium of communication accessible to all concerned; there was a trade paper which devoted special attention to the scientific and technological side of refractory materials, and if scientists would pay more regard to trade journals, much of the present overlapping and repetition of work would be avoided. Much of the apparent indifference among the manufacturers of refractories was due to two causes: Most of the firms were small and had not sufficient capital for research; and some of the more progressive firms had been unfortunate in the research work done for them by inexperienced students fresh from college. These considerations had induced him to start in practice as scientific adviser in 1901, and his clients felt fully justified in combining to maintain a central testing station and technological bureau dealing solely with clays, sands and their products. The method so successfully used in the development of the German refractory industries was to retain the ablest investigator by one firm or group of firms, so as to investigate all the problems arising, and not to be content with research carried out in State-aided colleges by men whose chief occupation should be educational. That method was free from the uncertainties of grants from the State, and the whole of the money was spent on the special problems for the benefit of those most entitled to it, while the universities were free to concentrate on questions of academic interest, for which they were expressly fitted. The analogous problems had been satisfactorily solved in the Portland cement industry by similar combinations of manufacturers, with complete success so far as they had gone; the Brown-Firth laboratory was another example taken from the steel industry. We cannot help remarking that Dr. Searle appears to advocate a peculiar co-ordination of pure and applied science, though we can feel with him to a certain extent; one might ask how his fossilised universities would train the scientific adviser.

Contenting himself, owing to the lateness of the hour, with a few remarks on "The Classification of Refractory Materials and Notes on Methods and Points for Investigation," Mr. E. P. Page, of Sheffield, said that this branch of science was still in its infancy, except as to materials like graphite and bauxite, and not ripe for classification. The customary distinction of acid, basic and neutral materials was arbitrary. The essential property was stability at all temperatures and conditions. Referring to different clays, substantially of the same percentage composition, Mr. Page showed that these materials might be as different as chalk and cheese and be classified in diverse ways.

Mr. Cosmo Johns, M.I.Mech.E., F.G.S., of Sheffield, contributed a paper on "Silica as a Refractory Material," dealing in particular with the application of this material for acid and basic open-hearth processes. The silica was used, Mr. Johns stated, as sand to form and to repair the hearths of acid furnaces, and as silica brick also in the basic process. Silica bricks had been made for more than a century, and the art was still in advance of the science. Among recent researches a paper by Fenner on the "Stability Relations of Silica Minerals" deserved attention, as it explained some of the anomalies noticed by Day and Shepherd (*American Journal*

* See ENGINEERING, vol. c. page 120, as to method and results and also other researches.

† See ENGINEERING, vol. lxxxvii, page 1, January 1, 1909.

of Science). Fenner noticed that the melting of cristobalite (about 1,625 deg. C.) really meant de-orientation of crystalline structure, and it was fortunate that silica had a melting-range, instead of a melting-point. The temperature of the walls of an open-hearth furnace was very difficult to determine; with an optical pyrometer Mr. Johns had found 1,650 + 50 deg., while the flame temperature was about 1,800 deg., the flame appearing bright on the background of the walls. The bricks carried the greatest load; but there was a greater margin of safety than might be thought, as only the face was exposed to this temperature. Examination of fractured surfaces of bricks which had done long service in furnaces showed the portion next to the interior of the furnace to be much darker and denser than the other parts; that "seasoned" portion was more refractory and stood temperature changes better than the original brick, and contained up to 15 per cent. by weight of magnetic iron oxide (the most stable oxide); this oxide was not in combination or in solid solution, as it could be picked out by the magnet. That so much iron oxide should improve the brick was noteworthy: the fact might merely indicate long "annealing," but the magnetite might not be a passive constituent.

Ferruginous quartzes were not sought for as raw material for bricks; yet a Japanese quartzite with 4.5 per cent. of iron oxide* had unexpectedly given a highly refractory brick, in spite of its dark colour, and it would be interesting to try the addition of magnetic iron oxide to bricks; in the mixture the oxide would not be disseminated through the material as in the quartz, but it would approximate to the seasoned bricks. Bricks containing iron oxide should be burnt in an oxidising atmosphere, to avoid the formation of possible ferrous silicates. This formation took place in the uptakes from the furnaces, and the bricks were corroded there by the reversals of the atmosphere.

Silica bricks were made by mixing crushed quartzite with a little lime and moulding and burning the mixture. The resulting complex mineral should stand temperature changes without cracking, be refractory at the highest furnace temperatures, resist reactions, and have a regular and small expansion coefficient. Differences in the size of the quartz fragments and in the nature of the heat treatment were perhaps more important than variations in the composition. The lime silicate, less refractory than cristobalite, was a necessary evil; the lime was required to bind the quartzite fragments, and the problem was one of grain size and packing. As the surface varied inversely with the size, large grains were desirable; but grains of uniform size gave a maximum of void spaces, hence there should be more than one size of grain. A continental firm made a very good brick from two sizes (7 and 3 mm.), with the fine material resulting from the crushing as third size; other makers used similar sizes, but there were departures from this practice calling for experimental research. Fenner's inversion temperatures: A quartz → B, 575 deg.; B quartz → tridymite, 870 deg.; tridymite → cristobalite, 1,470 deg. C., concerned fine mater al, and a flux had sometimes to be used; but the relations were by no means simple, and unstable phases appeared in certain melts. The raw materials of refractories were not pure, and purity was hardly desirable. The occurrence of definite phases could not be predicted therefore, and the petrological examination of the cold brick (after burning or use) could not throw much light on the constitution. Quenching fragments from furnace temperatures might yield information. After determining the correct texture, time-temperature curves could be correlated to the behaviour in service conditions, and the effects of reducing and oxidising atmospheres, the permissible range of temperature, and the use of catalysts and of various bonds might be investigated. As regards sands, Mr. Johns remarked that sand was used as received, except for drying. The grain should not be too small; the sand should be refractory, in a sense, yet it should frit when thrown into the hot furnace, without becoming viscous. Extreme purity of sand was no advantage when used in itself; the permissible range of impurity could be only tentatively suggested: Al_2O_3 up to 2 per cent. or more; Fe_2O_3 up to 5; CaO or MgO, 0·5; Na_2O or K_2O, 0.15 per cent., provided only one of these constituents were present. But sands of lower standards might possibly be used, and were used.

* According to a communication to Mr. Johns, by Captain Noda, Japanese Navy.

Several representatives of the Geological Survey of Great Britain and of the Imperial Institute presented communications on the sources of refractory materials in this country; the exhibits, both from the Geological Museum in Jermyn-street and the Imperial Institute, were examined with great interest. Mr. J. Allen Howe first made a statement on "The Recent Work of the Geological Survey on Refractory Materials." When the war broke out, he said, merchants, manufacturers and the Government had inquired about the mineral resources, and with the aid of what was left of his staff, the director of the survey, Dr. A. Strahan, had already produced five special reports on the mineral resources of Great Britain; a sixth, on refractory materials, was to follow. A good deal of information on the latter subject was scattered through memoirs; the museum also possessed the only long series of clay test pieces ever made in this country, by the late George Maw; that collection had often proved of value to engineers, and if only some organisation of manufacturers and trained experimentalists had followed up Maw's work, there would have been no need of a meeting like this to-day. In order to collect samples and information as to locality, geology and extent of deposits, the country had been blocked out into field areas, field staff units had been at work since last summer, and much material had already come in. Mines and quarries were visited and the producers of the raw stuff and materials were consulted. The principal users were likewise approached, and the first conference of this kind, arranged by Sir R. Hadfield, had been followed by a large number of conferences at other steel, iron, copper and smelting works.

They had not paid special attention to coke ovens, as the Refractory Committee of the Gas Engineers were looking after them [compare Dr. Colman's paper mentioned above] but they were in consultation with that committee. Some 1,500 samples, exclusive of typical bricks, had been received so far; though several isolated areas were still to be dealt with, the first stage of their task, the collection of raw materials and information, was nearly completed. The second stage, the chemical, petrological and textural examination, would take time, but they hoped soon to bring out a first portion, dealing with ganisters and silica rocks, a second portion on fireclays, and so on. Information as to refractoriness and other properties and tests was also to be incorporated in the report, though the methods adopted in preparing blending and firing could not be included. There would be, for the first time in this country, however, a publication dealing with all its refractory materials, and the records were to be continued.

Dr. Aubrey Strahan, F.R.S., director of the Geological Survey, was able to add some very encouraging remarks. The resources of Great Britain in materials, so far largely imported, were practically inexhaustible. Great Britain probably contained a wider and more varied assemblage of minerals than any other area of equal size in the world. Mr. Howe had pointed out that the Geological Survey was the only permanent organised staff of the country for the investigation of rocks and minerals in the field. The basis of the survey work was the construction of a primary 6-in. geological map of the whole country. The surveyors also noted down strata and outcrops which appeared of no value at the time; but the outcrops of certain sandstone beds in the coal measures and millstone grit of Yorkshire and South Wales, in which the well-known silica rock occurred, marked on old maps, had now proved of great service in this special task. The geologist had mainly to determine the reserves and characters of the raw materials. The manufacturer would be informed of the localities and properties of the rocks, specimens of the rocks themselves would be added to the collections of the Museum in Jermyn Street, where further information could be obtained. There had been a keen demand for the early volumes of their special reports, and the members of their staff had everywhere met with so cordial a reception that the report should be useful to the development of the industry.

Mr. T. Crook, of the Imperial Institute, referred to the work of this Institute, which, he said, had for many years been engaged in investigating the mineral resources of the Empire by means of mineral surveys and of laboratory research. The Empire was in quite a strong position as to refractory materials. Ceylon was a valuable source of graphite of exceptional quality, both in texture (flaky and fibrous) and composition; Canada also had considerable reserves; the flaky variety was found abundantly in a disseminated condition among the old rocks of East Africa and Nyassaland; a lower grade of amorphous graphite occurred in Natal. Chromite, chiefly valued as chromium ore, came from Rhodesia and from Beluchistan and Mysore, also from Quebec and Newfoundland. Bauxite was supplied by Antrim; the large reserves of Jubbulpore and Balaghat, in the Central Provinces of India, had hardly been attacked; very interesting also were the bauxite deposits of British Guiana, from Christiansburg and other places on the Demerara River, where a bauxite of 66 per cent. of alumina could be mined; these deposits had attracted North American capitalists. Magnesite was well represented in the Empire's mineral resources; India had for several years mined considerable amounts in the chalk hill deposits of the Salem district (Southern India), and deposits were now worked in Travancore; there were also important deposits at Malelane (Transvaal), at Heathcote (Victoria, Australia), and in various parts of Canada, notably in Quebec and British Columbia; at Atlin (B.C.) large stores of hydromagnesite were found which contained 20 per cent. of water, but little lime and other impurities, and which well repaid calcination. Talc and pyrophyllite, likewise of some importance as refractories, occurred in the Transvaal, Newfoundland and Vancouver Island; the quartzose pyrophyllite of the latter island had for some years been quarried and utilised, mixed with clay and shells, as raw material for fireclays. Zirconia, now so much in request, was obtained in the form of impure baddeleyite in Minas Geraes (Brazil), and also in Ceylon, though so far only in small quantities. The chief zirconia material had up to the present been the mineral zircon (67 per cent. of ZrO_2), of which large amounts existed in the pegmatite and gem gravels of Ceylon; Zululand, the Federated Malay States and New South Wales also supplied zircon. The monazite sands* were another possible cheap source of zircon; the non-magnetic residue of the monazite concentrates from the Travancore coast consisted largely of fine-grained zircon. Mr. Crook exhibited an excellent collection of these minerals from the Imperial Institute, the director of which, he mentioned in concluding, would be glad to give further information.

Dealing with "Refractory Sands," Dr. P. G. H. Boswell, of the Imperial College of Science, said that most of the refractory sands were not true sands in the geological sense, as they frequently contained clay. To a large extent the home resources could no doubt supply refractory sands; but certain desirable properties of those sands were not fully understood yet; geologists did not know what exactly to look for, and much systematic academical research by petrographic and other methods and works investigation were required to find the British analogue to certain foreign materials. Industrial refractory sands might be divided into three classes: (*a*) High silica sands (above 98 per cent. of SiO_2); (*b*) high silica and alumina sands (up to 20 per cent of Al_2O_3, silica and little else); (*c*) green sands, for moulding. There was abundance of (*a*), and there were also valuable deposits of (*b*) in this country; but the margins of profit were small, and freight and transport were very important factors. As regards (*c*), the best foreign materials had not been equalled yet; it was not fully known what constituted the superiority of the Belgian red and yellow sands, and the Pliocene and Lower Cretaceous should be thoroughly searched in this connection; the

* Monazites are phosphates of the rare earths, the raw material for incandescent mantles.

Tertiary and Cretaceous deposits of south-west England particularly seemed to deserve attention. Researches were especially desirable as to: mechanical analysis and grading; chemical analysis of each grade; mineral analysis of materials liable to decomposition, in order to decide what constituent formed the bonds; water-holding capacity, for intervals of 10 deg. C. up to 110 deg., and for greater intervals afterwards; conductivity; refractoriness; pore space and permeability. A report on British resources of glass-making sands (by Dr. Boswell) was just being published by the Ministry of Munitions; these sands fell under classes (*a*) and (*b*); but the report also referred to refractory sands, the home resources for which were much larger. Admirable work had been done by the Geological Survey, and the number of people working on refractories in this country was astonishing; but there was much wasted haphazard effort and too little co-ordination.

Dr. W. Rosenhain, F.R.S., remarked that Germany, and especially America, had been successful in electric-furnace experiments on refractory materials, and the latter country had brought out carborundum, siloxicon, alundum and other products, with which England could hardly compete. As regards zirconia, the future seemed to lie in purified, not in crude zirconia. There were ores with 90 per cent. of zirconia. But baddeleyite (density about 4) occurring in Ceylon and Brazil, was much more abundant, and though it contained only about 75 per cent. of ZrO_2, 13 of SiO_2, 1 of TiO_2, 3.5 of Fe_2O_3, 2.2 of CaO, 1.6 MgO and 1.1 Al_2O_3, it appeared up to 1,650 deg. C. to be as refractory as pure zirconia, so far as his laboratory tests went. The difficulty was that zirconia was apt to form carbide, and that the product had to be baked at the highest temperatures, because it was a very bad conductor of heat and went on shrinking for a long time. The iron could partly be extracted from the brown mineral, which then turned white with the aid of sulphuric acid; he had used the purified mineral in his optical glass researches. As regards the liability to crack, that always depended upon two sets of properties: (1) The temperature gradient set up, a question of conductivity, specific heat and density of the material; (2) coefficient of expansion, elasticity modulus and tensile strength. A given rise of temperature per millimetre depth would give rise to a certain expansion, and if this expansion were resisted by the non-expansion of the adjacent layers, a tensile stress was set up in the latter equal to the tensile stress that would be required to produce the same expansion by elastic deformation; when this stress was greater than the tensile strength of the material, a crack would result. This view was based upon work done on glass, described in Hovestadt's book. The tensile strength of non-metallic bodies (glass, fireclay, &c.) was always very low, however, though their compression strength was considerable. A body which would not crack with sudden temperature changes should have high specific heat and density, high tensile strength and elastic modulus, but low thermal conductivity and expansion coefficient.

Professor T. Turner, of the University of Birmingham, remarked that they had hoped to have a refractory department, as at Sheffield. Porosity was very important, and might be measured by drawing air through the material. He had also experimented on volume changes in coke ovens. Dr. Mellor's remark that round grains did not give the closest packing was only correct for spheres all of one size; with small and larger grains alternating a very close packing could be secured. Dr. R. S. Hutton, of Sheffield, reminded the meeting that the Faraday Society had discussed these problems in its early years when he had read a paper on the conductivity of furnace materials; he had continued those experiments in the electro-metallurgical laboratory of Manchester, studying also the shrinking of magnesia and silica; but more general researches were required.

Mr. W. J. Jones and Mr. A. Duckham, of the Ministry of Munitions, Professor Donnan, Mr. W. C. Hancok, Dr. J. A. Harker, Mr. Kilburn Scott and others also spoke. We have not noticed the communications in the order they were made, grouping them to a certain extent, and have had to condense our remarks. A striking feature was perhaps that so little reference was made to the porosity of the materials, which is undoubtedly one of the most important features; but this property is difficult to test for—quite apart from the difficulty of combining porosity and strength—and little research work has been done in this particular field.

LITERATURE.

Aeronautical Engines. A Critical Survey of Current Practice with Special Reference to the Balancing of Inertia Forces. By FRANCIS JOHN KEAN, B.Sc. (Engineering). London: E. and F. N. Spon, Limited. [Price 6*s.* net.]

ALTHOUGH Mr. Kean describes his book as a critical survey of current practice it is not an exhaustive treatise on the subject, and, indeed, for anyone who has followed closely the development of the aeronautical engine, this book contains little that is new. For some time past a scheme for training men of the Royal Flying Corps has been in operation at the Polytechnic, Regent-street. This book has been written from notes compiled for a course of lectures given as part of that training. It is an introductory study suitable for those who have some general engineering knowledge and who wish to become acquainted with the characteristics of the petrol engine for aeroplane work.

Weight per horse-power, fuel and oil economy, balancing, number of cylinders and firing order, the carburettor and the magneto are discussed in the first seven chapters. The treatment is non-mathematical and the style is simple and clear. The eighth chapter is devoted to descriptions of typical engines and is well illustrated by photographs.

The incorporation of sheets of rather complicated diagrams of inertia forces for Vee and radial engines, without adequate description, in a book of this character is surprising. The chapter on balancing would have been much improved by the inclusion of such a description and by some mention of balance of rotating parts. As the allowable variation in weight of the exhaust valve in the rotating cylinder "Gnome" engine is the same (about 0.5 to 1 gramme) as that for the piston and connecting rod of the radial-cylindered "Salmson" engine, the difference in the balancing qualities of the two types is not so great as would appear from Mr. Kean's treatment.

Other points which might have been described more fully with advantage are—the planet gearing of the Salmson engine and the auxiliary hand-operated starting magneto of the Beardmore engine. The casual mention of the latter device, following as it does almost immediately upon a discussion of two-point ignition, is unfortunate and confusing.

These few defects, taken in conjunction with several obvious slips of the pen, leave an impression that the book has been written somewhat hurriedly, and that upon revision it is capable of great improvement with slight alteration.

In its present form the book should prove of considerable value to the class of readers for whom it appears to have been intended. The bold type employed makes the book comfortable and attractive to read.

BOOKS RECEIVED.

United States Department of Labour. Bureau of Labour Statistics. Whole Number 188. *Report of British Departmental Committee on the Danger in the Use of Lead in the Painting of Buildings.* Washington: Government Printing Office.

United States Department of the Interior. Bureau of Mines. (1) *Coal Mine Fatalities in the United States,* 1915. (2) *Monthly Statement of the Coal Mine Fatalities in the United States, February,* 1916. Compiled by ALBERT H. FAY. Washington: Government Printing Office.

Union of South Africa. Report of the General Manager of Railways and Harbours, 1915. Pretoria: Government Printing and Stationery Office.

Universidad Nacional de la Plata. Memoria Correspondients a 1914. *No.* 4. La Plata: Facultad de Ciencias Fiscias, Mathemáticas y Astronómicas. [Price pesos 0.80.]

Electrical Measurements and Testing Direct and Alternating Current. A Manual to accompany Timbie's Electrical Measurements in Direct and Alternating Current and Karapetoff's Elementary Electrical Testing. By CHESTER L. DAWES. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 3*s.* net.]

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several Colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, E.C.

New Zealand.—H.M. Trade Commissioner in New Zealand writes calling attention to a notice which appeared in the official *New Zealand Gazette* to the effect that, as a result of a poll of the ratepayers of the Borough of Pukekohe (North Island), it has been decided to borrow the sum of 12,000*l.* for the purposes of road and street improvements, improvements and additions to the waterworks, and the installation of electric lighting in the borough.

Republic of Colombia.—The *Diario Oficial*, Bogotá, publishes a Presidential resolution authorising the Municipal Council of Bogotá to raise a loan of up to 5,000,000 pesos gold (1,000,000*l.*) to be devoted, *inter alia*, to the extension and improvement of the municipal tramway and aqueduct, the construction of a slaughter-house, market buildings, public schools, and cheap houses for workmen. The *Diario* also publishes the text of a contract entered into between the Colombian Government and Señor Carlos Palacio, for the production of sea salt on the Pacific Coast of the Republic. The concessionaire is to establish a factory for the production of sea salt (either in crystals or in compressed form) on one of the islands or on the coast of the bay of Tumaco, within 15 months from the date of the approval of the contract. The term of the concession is 10 years.

French West Africa.—According to the *Depêché Coloniale*, Paris, a decree, dated October 11, authorises the execution of preliminary construction work on the section of the Thiés-Kayes Railway between kilometres 445 and 510 at an estimated cost of 1,575,000 francs, and the construction of the abutments of the Falémé bridge at a cost of 270,000 francs. A total sum of 1,180,000 francs is authorised to be expended on the purchase of material for these works. [In reference to the foregoing it should be borne in mind that the exportation to French West Africa of certain kinds of railway material and bridge work is prohibited.] (25 francs = 1*l.*, par rate.)

GRAPHITE IN THE UNITED STATES IN 1915.—The production of natural graphite in the United States in 1915 represented 19 per cent. of the imported graphite, according to the contribution by Edson S. Bastin to the "Mineral Resources of the United States." The production of the years 1913, 1914, 1915 were 4,775, 4,336, 4,718 short tons, valued at 295,756, 324,118 and 429,631 dols. The imports exceeded in value (2,241,163 dols.), but not in quantity (23,075 tons), those of any previous year. Most of this graphite probably came from Ceylon, and the imports credited to France were probably due to Madagascar. The figures given do not comprise manufactured graphite. The Acheson Graphite Company erected new Gredag (grease and graphite for lubrication) works in 1915, and had altogether 40 furnaces going, reckoning also the works on the Canadian side of Niagara Falls; the bulk production was estimated at 2,542 short tons (value 99,633 dols.), but that figure concerns only ordinary, not the special manufactured graphites. The demand for graphite electrodes rose very much; electric steel furnaces alone are supposed to have increased by 78 per cent. during 1915. The graphite electrodes made at Niagara Falls range from $\frac{1}{4}$ in. up to 12 in. in diameter and up to 77 in. in length.

SENSITIVENESS TO DETONATION OF TRINITROTOLUENE.—The high prices of mercury, wanted for the fulminate detonators of high explosives, have called forth a search for substitutes for the mercury fulminate. This fulminate is commonly mixed with potassium chlorate or with lead azide (PbN_6), and trinitrotoluene (popularly known as TNT) and trinitromethylnitramine or tetranitromethylanilin (known as tetryl) can themselves to a certain extent be utilised as detonators. Papers on recent investigations of this problem have been published, chiefly in German periodicals. On behalf of the Bureau of Mines the question has been taken up by Messrs. G. B. Taylor and W. C. Cope (Technical Paper 145). They test in particular the suggestion of M. Giua (*Gazzetta Chimica*, July, 1915) that TNT could be made more powerful and also more sensitive by being mixed with tetryl. They fuse these two bodies together in various proportions, fill a copper shell, 5 mm. in diameter, with 0.4 gramme of the mixture, place the primer (fulminate with 10 per cent. of potassium chlorate) on the top, force a perforated reinforcing cap (thin copper, 9 mm. long) into the shell by a pressure of 206 kg. per sq. cm. for a minute, crimp the fuse into the shell and apply the sand test of C. G. Storm and Cope (Technical Paper 125). In this test the shell is buried in 100 grammes of sand contained in a steel cylinder (bored block of steel), and after firing they screen the sand (which had previously been screened) to find out how much will pass through a 30-mesh screen. A series of experiments are made to ascertain the minimum weight of fulminate that will effect complete detonation of the high explosives. When a small crushing effect was observed some unexploded TNT or tetryl was always found. It resulted that about 0.32 gramme of fulminate and chlorate are wanted fully to explode 0.4 gramme of the high explosives, and that TNT is not only less sensitive than tetryl, but also much more liable to become insensitive by the presence of moisture. The pure TNT failed to detonate when it had taken up 0.003 gramme of moisture, simply by being stored over water. Furtner experiments are to follow.

23 IN. BY 28 IN. CAST-STEEL LOCOMOTIVE CYLINDERS.

We illustrate on the present page a locomotive cylinder steel casting manufactured by the American Steel Foundries, Chicago, for the American Locomotive Company, to be used on engines of the Birmingham and Southern Railway. The casting is known as a 23-in. by 28-in. cylinder. Its principal dimensions are the following :—

	In.
Cylinder bore	23
Length of cylinder, face to face ...	39
Outside diameter of flange	30
Steam chest bore	13½
Length of steam chest, face to face ...	42
Steam admission pipe	6½
Steam admission pipe flange	13½
Length of saddle flange	42
Radius of saddle flange	38½
Height of joint flange	47½
Length of joint flange	42
Length of saddle body	31
Horizontal distance of centre line of cylinder to centre line of steam chest	7
Vertical distance of centre line of cylinder to centre line of steam chest	24
Total height over flanges of cylinder and steam chest	48½

The single casting weighs 7,310 lb. The locomotives on which these cast steel cylinders are used are of the consolidation type, having a total length of 39 ft. over all, a total wheel-base of 23 ft. 8 in., and a driving wheel-base of 15 ft. There are 8 driving wheels, having a diameter of 53 in. at the tread.

Such castings are very difficult to make, owing to the large amount of core work required.

THE GRINDING AND POLISHING OF OPTICAL SURFACES.

A numerously attended meeting of the Optical Society was held at Burlington House, London, on Thursday, November 9, the President, Mr. F. J. Cheshire, in the chair, when a paper, illustrated by lantern slides, was read on "The Grinding and Polishing of Optical Surfaces" by Mr. James W. French, B.Sc. (member), of Glasgow.

The author in the course of his paper pointed out that the polished surface of metals consists of a layer which covers over small scratches and pits in the underlying material. When the surface layer is removed by etching, the scratches and pits are exposed. When the polished surface of glass is etched, numerous fine scratches reappear, and it has been wrongly assumed that glass behaves likes metals.

For purposes of description, the original material is referred to as Alpha glass and the modified material constituting the surface layer as Beta glass. Clean scratches comparable with those on metal cannot be formed on the Alpha glass. The material splinters in the characteristic conchoidal fashion. Perfectly clean scratches can be formed in the Beta layer; they can be filled in by further polishing, and it is these scratches that reappear after etching. The cohesion of the silicates constituting the surface layer is too small to permit of the bridging over of pits, such as minute air bells, that are just exposed, and no evidence of any inclusion of foreign matter in the Beta layer scratches has been obtained.

An optical glass surface is produced as follows:—The action of the pitch polisher loosens or liquefies, as it were, the surface layer of molecules, which rearrange themselves uniformly under surface tension. The polishing medium subdivides, breaks up, and removes the surface layer, thus exposing the underlying material. This process then repeats itself and a perfect surface is obtained only by the removal of material beyond the bottom of the hollows produced in the glass during the earlier abrasion process. The importance of avoiding the production of deep hollows during the smoothing operation is emphasised.

A soft cloth polisher, unlike a hard pitch polisher, sinks into the hollows of the glass and produces an irregular polished surface. The rate of removal of material is slower with cloth, and for high quality optical surfaces cloth polishers should not be used at any stage. Surface-layer material, as removed by rouge, has been collected. It consists largely of granules corresponding closely in appearance and size with the granules of rouge employed.

The thickness of the surface layer was measured as follows:—A piece of polished crown glass was heated until the surface layer cracked just as glaze cracks on porcelain. From a transverse section, which was cut and polished, it was seen that the cracks were of uniform depth and by measurement of a number of specimens the depth of the layer was found to be about 1/200 mm., that is, about eight wave lengths.

Our Rails Abroad.—Our exports of rails in October this year amounted to 6,929 tons, as compared with 13,640 tons in October, 1915, and 37,005 tons in October, 1914. In the 10 months ended October 31 this year the aggregate shipments amounted to 43,387 tons, as compared with 219,592 tons and 402,944 tons respectively. Our rail exports to the Argentine Republic have practically ceased, having amounted to only 69 tons in the first 10 months of this year, while in the first 10 months of 1914 they attained a total of 26,404 tons.

STEEL LOCOMOTIVE CYLINDER CASTING.

CONSTRUCTED BY THE AMERICAN STEEL FOUNDRIES, CHICAGO.

Prices of Steel and other Metals.—There has just been issued from the Ministry of Munitions of War, Whitehall-place, S.W., comprehensive tables showing the basis prices and extras permissible for (*a*) steel ship, bridge and tank plates; (*b*) thin plates; (*c*) S. M. boiler plates for the home trade; (*d*) steel sectional material; (*e*) small steel angles, tees and flats; (*f*) steel rounds, squares and hexagons; (*g*) small steel rounds, squares and hexagons; and (*h*) joists. These, if reproduced here, would occupy too much space, but all who are interested in the subject can, by communicating with the Ministry of Munitions of War, receive copies of the returns. A similar list of authorised extras chargeable on bar iron has also been made, and it is notified that the following have been added to the list of war materials to which the regulations of the Defence of the Realm Act apply, namely:—Steel hexagons, steel rounds and squares (tested), steel scrap of the following classes where sold without guaranteed analysis: heavy steel melting scrap and steel turnings and borings.

Engineering Work in Mesopotamia.—The despatch from Sir Percy Lake, K.C.B., issued this week, indicates that a considerable amount of engineering work is in progress in Mesopotamia, although necessarily few details are given. Two new railways are under construction, water communications are being dredged and generally improved, and at Basrah extensive engineering works have been made, and wharves have been built at which ocean-going steamers will be able to unload. General Lake specially mentions the able assistance given by Mr. W. Grant, Admiralty overseer at Abadan, in preparing river craft for service. The work of the Indian Marine comes in for prominent notice. It is stated that the rapid growth of its duties may be gathered from the fact that whereas in January, 1916, there were 19 permanent and 21 temporary officers and 525 other ranks employed, by July the number had risen to 40 permanent and 163 temporary officers and 3,981 other ranks, besides native labourers. "The necessity for assimilating this large influx of newly appointed officers and men threw a heavy strain on the permanent cadres, who were also faced with many unforeseen demands. That under these conditions its duties have been carried out with a considerable measure of success is distinctly creditable to the service." We quote further regarding the preparation of the port of Basrah, as follows:—"The appointment of Sir G. C. Buchanan to the Force as Director-General of Port Administration and River Conservancy, has been of undoubted value. Owing to the difficulty experienced in obtaining certain stores and equipment from India and Burma, and to sickness among the supervising staff, the work of developing the port of Basrah, and of dredging and improving water communications generally, was at first delayed. It is now, however, well in hand, and the results already achieved are sufficient to show that the projected measures will have a far-reaching effect on the business of the port and our all-important river communications. Sir G. Buchanan especially desires to mention the assistance he has received from Lieutenant J. G. Grant, R.E."

The Panama Canal.—In July of this year, the month of greatest traffic since the reopening of the Canal in April, says *The Panama Canal Record*, the aggregate length of the 149 ships passing through the Canal was 53,905 ft., or approximately 10.2 statute miles. The average length of the vessels was 361 ft., and their average draught 20.9 ft. The vessel having the largest draught was the Ohioan, drawing 29 ft. 4 in. The one having the smallest draught was the Panama Railroad barge No. 71, drawing 2 ft. The vessels having the greatest length were the Siberia and the Korea, each 552 ft., and the vessel having the least length was the Sir Francis, 32 ft.

The Late Professor H. M. Waynforth, M.I.M.E., A.M.Inst.C.E.—By the death of Professor H. M. Waynforth—until recently professor of engineering in King's College, London—engineering teaching has suffered a great loss. He died on Sunday, November 5, after a long illness. Born in 1867, he was educated at the Haberdashers' School and at the Finsbury Technical College, his apprenticeship being served at Messrs. Bennett and Sons, engineers. He was assistant to Professor Perry at Finsbury for some time, after which he went to Mason College, Birmingham, as demonstrator in engineering, leaving Mason College to join the engineering staff of King's College, London, in 1896. He was appointed assistant professor of engineering in 1902 and university professor in 1912.

Department for the Raw Materials of the Empire.—An inter-departmental Committee, presided over by Mr. Harcourt, has arranged the respective spheres of work and co-operation, in dealing with commercial inquiries, of the new Commercial Intelligence Department of the Board of Trade and the Imperial Institute, which in recent years has become a central Department for information and investigation respecting the sources and uses of the raw materials of the Empire. In future the Technical Information Bureau of the Imperial Institute will answer all commercial inquiries respecting the sources of supply, technical uses and value of raw materials within the Empire, and will be responsible for supplying all information required in order to bring the producer overseas in touch with the manufacturer at home. Inquiries as to immediate supplies may be addressed either to the Board or to the Institute as may be most convenient, but the Commercial Intelligence Department of the Board of Trade will, as a rule, be prepared to deal with inquiries for immediate supplies of well-known raw materials which can be obtained at once through ordinary trade channels. In answering those inquiries in which special statistical or trade information is required in addition to technical information, the Board and the Institute have arranged to co-operate. Investigations of the possible industrial uses of raw materials will as heretofore be dealt with by the Imperial Institute. The arrangement proposed by the Committee has now been accepted by the Secretary of State for the Colonies, the President of the Board of Trade, and by the Executive Council of the Imperial Institute.

THE INSTITUTION OF CIVIL ENGINEERS.

Address of Sir Maurice Fitzmaurice, C.M.G., M.A., M.A.I., LL.D., President.*

(*Concluded from page* 470.)

I did intend to say something more about education in schools to-night, but having read during the last six months the debates on education in both Houses of Parliament, the speeches made at various important meetings, and the voluminous correspondence and articles in different papers and journals on the subject, I do not feel that my experience justifies me in taking up your time. Everyone acknowledges *now* that science has in the past been neglected in education in this country. Everyone, or nearly everyone, agrees *now* that the teaching of science must be one of the principal features of the national education. In the debate in the House of Lords on July 26 last the Marquess of Crewe stated it was the intention of the Government to set up a committee to review generally the whole field of national education, and another small committee to look into the question of scientific teaching. Two committees have so far been appointed, one to consider the teaching of natural science and the other modern languages. I hope there may be some result from the labours of these committees. During the last twelve months committees have sprung up like mushrooms, and it must be getting difficult to find the right men who can give time to them.

Before leaving the subject I may, however, say that I am one of those brought up on compulsory Latin and Greek to the age of 19. Both languages were taught to me in such a way as to develop the minimum amount of interest in my mind with regard to the many instructive books which I read. I think this teaching did me some good and certainly no harm. I have often since thought that I might have received a lot of good from it if these languages had been taught in an interesting way.

On the other hand, I was taught mathematics and such experimental science as was possible at that time by a man whose teaching was alive and who made the commonplace things interesting. In fact one could not help learning from him. I only mention this because the contrast between the teaching of the two subjects was great, and because I want to draw attention to the fact that whatever educational programme may be devised a great lot depends on the teachers. The live teacher is one of the problems.

While I need hardly say that I am extremely keen about a radical alteration in our teaching so that scientific education may be kept all the time in the foreground, I do not wish to see young men growing up without what in an old-fashioned way would be called a good general education. We at this Institution have been altering our examinations and practical requirements from time to time so as to raise the scientific standard required for students and associate members, but we have not forgotten the value of a good general education. I think, however, the time has arrived when a knowledge of one or more modern languages should be made obligatory. I am sure that in the future the Institution will not fail to retain its general education requirements, while at the same time helping on scientific training in every possible way.

I have frequently been asked by parents of budding engineers, and by young engineers themselves, for advice, and the remarks which I have to make on this subject are specially directed to the students and the very young members of the Institution. The examinations by the Institution, or the corresponding ones at the universities, which have now for some time been required before a young engineer can become an associate member of the Institution are, of course, only the groundwork for the work to come later on. Nothing can take the place of experience and actual contact with difficulties. It is therefore necessary that an engineer should devote his time to getting all experience possible.

I remember being told many years ago, by a friend who had passed through the Engineering School at Cambridge University, that he asked the professor of engineering at that time for some advice on what he should do. The answer he got was: "Try and get into some large shops, or on to some large works; if you can't get taken on as an assistant or improver, try and get taken on as an assistant timekeeper." There is something to be said for that advice.

I have on one or two occasions been asked by a young engineer whether, of two posts offered to him, he should take that of one among many assistants on a large work with a small salary, or that of resident engineer on a small unimportant work at a considerably higher salary. Without hesitation I recommended the former position. I knew that on the large works he would see a little of almost every class of work, that even the temporary works of the one were probably more important than the permanent work of the other, and that the fact of being on a large work would be of great assistance later on and would stand to him all his life. He would also have the advantage of daily intercourse with other engineers, and the emulation and friendly rivalry between them would lead to efforts on his part to hold his own. There also exists on large works a feeling which I can only describe as engineering atmosphere, which may have a real influence on the life of a young engineer.

Experience and the passing of hard engineering examinations are, however, not the only requisites for success in our profession. I suppose there is no class of engineer more in request than the resident engineer or assistant engineer with experience who can "get on" with people. Engineers are afraid of assistants who can't get on with people. Such men irritate clients; they cause trouble whether they are on the engineer's or contractor's side. The capacity of getting on with people and still holding one's own has a distinct money value, and a very high one.

Closely akin to it is the one of being fair in dealing with questions which arise on works. The resident engineer and the contractor's engineer who are open with each other, and will not take any unfair advantage of one another, have both obtained a reputation of great value, and which may have a far-reaching effect even on both their firms.

In my opinion there is nothing which so much enlarges a young engineer's breadth of view and gives him a feeling of self-reliance as a few years' work abroad. The ideal conditions in connection with this are that it should be after some years' work at home, and be on works under construction by a British firm: but these ideal conditions are not, of course, always possible. One can only acquire knowledge of how works are carried out abroad, and the differences between such works and those in this country, by actually being engaged on the details of construction. In going abroad, young engineers should be careful, if possible, not to break any engineering connection which may have been formed at home. I personally have always considered it was extremely fortunate that I was employed for seven years on undertakings outside this country. In view of foreign work, it is essential that a young engineer should know well at least one foreign language. This knowledge will often be the deciding factor in gaining an appointment.

All young engineers should take every opportunity of carrying out experimental work. Such opportunities occur on nearly every undertaking. It need not be original work, as that is not always possible, but even the repetition of work previously done gets one interested and accustomed to that class of work, and it may be the means of correcting and enlarging the work done by others. The great help in this kind of work is the cultivation of observation. Indeed, if our eyes are open we may often see experimental investigation being carried out, often in the streets, especially in and near large cities like London.

I mentioned in this Institution, some time ago, that I hoped, when the finances of the Institution had recovered from the effect of the large expenditure on our new building, consideration might be given to setting aside an annual amount for certain experimental work. We have in the past subscribed largely to experimental work at the National Physical Laboratory, and to work undertaken by committees of members of the Institution, but the idea I had was on rather different lines. Very frequently the engineer in charge of works or shops sees opportunity for carrying out experimental work with very little money expenditure, but frequently that small amount of money cannot be found. If there were a fund available from which grants could be made in such cases for certain definite experimental work, I consider it would be very valuable, both to the members as a body and to the member carrying out the investigation. In the latter case the member would discover that he got more real knowledge by carrying out a small piece of experimental work himself than if he had read about ten times the amount of work carried out by other persons.

A quality which an engineer's work frequently develops is that of organisation, and this, if cultivated, frequently leads to very high positions. We have seen in this country, and also in America and the East, engineers who possess the faculty of organisation in control of some of the largest railway systems. No large enterprise can be carried out successfully without capable organisation. Engineers who have, or who develop, this quality may often, although not endowed with exceptional engineering ability, attain to positions not open to those who are devoted to engineering work solely. I think I am hardly wrong in saying that our most successful contractors owe their success in great measure to their organising capacity, and engineers with the same quality are indispensable to them.

I think I have said enough to show young engineers that success depends on many matters besides knowledge of engineering, and that even with a moderate knowledge of it other qualities may be developed which command a high money value and are the means of attaining to important positions.

There now comes probably the most difficult question of all for a young engineer, the chance which makes him known, the opportunity by which he can show that his qualities have been undervalued. There are many curious ways in which this opportunity arises. He may work steadily for many years, and it may suddenly come in the most unexpected way, and it generally does come once if deserved.

I read a short time ago in a Canadian engineering journal an article headed, "What is Luck?" and I quote the following from it:—

"You often hear it said, 'That fellow is certainly lucky.' As a rule the luck in his case consists in getting up at six in the morning, living on half what he earns or less, meeting his appointments, minding his own business, working like Sam Hill, and always keeping an eye on the track ahead. There may be exceptions, but this is the general rule."

I do not think this quotation is a good definition of luck, but it is a very good one of the road along which luck is generally found travelling.

I am not, however, going further into this question to-night, except to point out that I am not at all sure that young engineers realise the importance of attending the meetings, joining in the discussions, and contributing papers to this and other institutions. I don't think I have ever written a paper, or got out notes for a discussion, without discovering that there were several points on which my information was deficient in some particular, which otherwise I should not have known it was necessary to look further into. It is extremely difficult in many cases for even a very good young engineer to get himself known, and the reading of papers and joining in discussions is almost the only legitimate form of advertisement open to him. I can bring to mind, in my own experience, two cases where speaking at this Institution was the means of obtaining two excellent appointments. I happened to be particularly impressed by the practical remarks made here by two young engineers whom I had not known or heard of before. Very shortly afterwards I was asked to suggest men for two good posts, and after I had made a little inquiry I recommended these two men. They fully justified their selection, and I think are now on their way to high places in the profession.

I began this portion of my remarks with the idea of speaking on the want of success in individuals, but in some way I seem to have veered round to speaking of a few of the ways to success. It is better that it should be so: it is a much more pleasant subject.

I take the opportunity of saying a few words with reference to the difficulties which have arisen between employers and employed in recent years, as being matters which have a good deal to do with the success or otherwise of engineering works. During the period of the war it has been extremely satisfactory to find that many of these troubles have been shelved for the time being. The temporary truce has, however, in some cases not been carried out so far as one would wish and expect, bearing in mind the serious struggle in which we are engaged, and considering that everyone should bear some share of the loss and discomfort which war entails. We can, however, never forget the great part played by labour and labour leaders in this war, and we must remember that nearly all labour troubles which have arisen have been in direct opposition to the wish and advice of the trade union officials.

It is, however, with reference to the relations between employer and employed during times of peace with which I am most concerned to-night.

We had at this Institution, towards the end of last session, a most interesting and brilliant lecture which dealt, among other things, rather fully with some labour questions. I did not agree with all the propositions then laid down, but many of them were such as to invite serious consideration.

I had for many years the direct control of a large body of working men, and have had opportunities of inside knowledge with reference to many labour disputes with which I had no direct connection. The two points which struck me as fundamental in nearly every case were that the employer should pay a good living wage, and that the employed should do a good honest day's work, or perhaps I should say in some cases an honest week's work. The so-called "restriction of output" policy which some trades indulge in seems to be the first step in a most vicious circle. It certainly does not lead the employer to look favourably on proposals for increase of wages. It must be extremely irritating for him to know that the output per man could be easily increased in some cases, without undue exertion, and that under such conditions he could cheerfully concede an increase in wages. This policy is not confined to our own islands only.

I had an opportunity, some time ago, of discussing the question with one who had full knowledge of labour conditions in a certain State, and he informed me that, during 10 years, wages in his area had gone up 40 per cent. and the output per man had gone down 30 per cent. The general conditions no doubt justified the increase of wages, but there seemed to be no reason for the diminution of output.

We all wish to see labour contented. In Burke's speech in 1775 on conciliation with America, he said, "The question with me is not whether you have a right to render your people miserable, but whether it is not your interest to make them happy." I think that expresses our view with regard to labour to-day.

It is impossible to expect a high standard of duty to exist at all times among workmen unless they can live under such conditions as will allow them a chance of bringing up their families decently and making some adequate provision for old age. I am quite aware of the advantages as regards free education, medical attendance, out-of-work benefits, old-age pensions, and sometimes free meals for children, which exist; but better wages than those existing before the war, with a greater feeling of responsibility by the individual would, in my opinion, be much better than all these free advantages, with the exception of that of education. Organised labour has great powers and correspondingly great obligations, and it ought to be in a position to begin these obligations at home. If obligations and responsibilities do not exist in the elementary matters there is very little chance of their real existence when large questions have to be solved.

It is often difficult for the mass of labour to understand the cost of finding large sums of money to finance great industries, and that such money has to be paid for out of profits. It is difficult for labour to realise the risks which capitalists have to take and the fact that in many works large sums are spent on research work which may only give a return after a long period, or may in many cases appear to give no return, if it be considered that negative results have no value, which is far from being the case. It is also sometimes difficult for labour to understand that the work and organisation of one man may in some undertakings mean a difference in profits of hundreds of thousands of pounds, or the difference between success and failure, and that such men and their immediate assistants deserve and earn the large sums they receive. It is on these accounts that labour often considers that it does

* Delivered on Tuesday, November 7, 1916.

not get a fair share of the profits. I do not mean to say the profits are always fairly divided, and it would be difficult to say what a fair division should be.

I also do not believe the working man has any idea how the prosperity of this country, and with it his own prosperity, depends on our export trade, or how our manufacturers have had to meet the fiercest and sometimes unfair competition of other nations, not only in foreign countries but in our overseas Dominions. There is, however, nothing surprising in this want of knowledge when we remember that very few of us realised a few years ago how Great Britian was exploited by German competition, frequently underhand and unfair, with the object of capturing our vital industries and getting control of a great deal of our finance and trade. We have, however, learned a great deal in the last two years, and I think many working men are not above taking interest in such questions.

How is it possible permanently to raise the wages of the working man beyond those existing before the war? Is it reasonable to expect that a greatly increased output per man can be obtained without undue exertion? We all know it is possible. It means that employers must provide the best modern machinery and that men and trade unions must give up the idea of restricting output. It means that capital has to obtain such a measure of the confidence of labour as is necessary to convert men and trade union officials to the view that increased efficiency will be to their great advantage and give increased comfort and health. This can only be done when it can be shown that under such conditions there will be plenty of work to go round for all, and it means that our trade has to be increased.

This leads at once to the question of the national campaign for maintaining and increasing our trade, but this is outside the scope of my address.

I do not mean to say that this Institution is not a place to discuss questions of industrial and commercial policy. On the contrary, I think it would be well if we gave more consideration to such subjects, and many of our members are well fitted for dealing with such questions. I may, however, say that it is a source of much satisfaction to know that great efforts are being made by the British engineering industry and the Government to be ready when the time comes. I hope the Government will not be above taking the advice given by those who are fully conversant with all the aspects of international trade competition.

I consider one of the most hopeful and important events which has occurred recently in connection with our trade is the speech of the Prime Minister in the House of Commons on August 2 last, when dealing with the White Paper on the proceedings of the Economic Conference of the Allies, held in Paris in June of this year.

Mr. Asquith gave, in the beginning of his speech, the two main objects of the Conference. "One was to convince the enemy that the Allies, whatever their individual points of view may be on economic matters, are resolved to wage this war with as complete unity and determination in the economic as in the military sphere. The second object was to make such preparation for the period following on a declaration of peace as seemed essential to the Allies in view of the known attitude and will of Germany."

He drew special attention to the extraordinary enterprise and resourcefulness shown by a large number of British industries since the war broke out, and laid particular emphasis on two tendencies. "The first is the development of trade associations for common action at home and abroad raising the average standard of production. The second is the recognition of the leeway which we have to make up as regards scientific research and the utilisation of its results and its application to technical and industrial purposes."

He concluded his speech by saying: "No one who has any imagination can possibly be blind to the fact that this war, with all the enormous upheaval of political, social and industrial conditions which it involves, must in many ways, and ought to if we are a rational and practical people, suggest to us new problems or possibly modifications in the solution of the old ones. I would regard it as deliberate blindness to the teachings of experience if you were to say we had forgotten nothing and had learned nothing from a war like this. I trust and believe we shall be able . . . to work out a policy of common action which will make the peace which is to come at the end of this war a lasting peace and a peace which will redound not only to the credit of our arms but to the stability of our industry and finance."

I make no apology for quoting at some length from the Prime Minister's speech, because it can only mean that the whole power of the Government will be placed at the disposal of our trade; that, as Mr. Asquith stated, steps will be taken to ensure protection against dumping and other unfair competition, and that we shall never again be dependent on enemy countries as regards essential industries. It means that Australia and Canada, whose representatives attended the Paris Conference and approved its resolutions, together with our other Dominions beyond the seas, have set their seal to a united empire for purposes of peace as well as for war.

However important the Prime Minister's declarations, and however necessary the help of Government, I attach still greater weight to the spirit which is at present animating our commercial leaders. The thorough-going determination of our manufacturers to organise British industries for more efficient production, and the steps being taken for pushing our trade outside these islands, are certainly on a different scale from anything previously attempted. The first part of the work to be carried out is put so clearly and shortly by the president of the Federation of British Industries that I quote his words. The objects of the association "may be summed up briefly as the organisation and development of industry now and after the war in co-operation with labour and in conjunction with the Government and Government Departments."

I hope those who are dealing with the development of our foreign trade will not fail to include among other matters full consideration of the important question of the adoption of the metric system of weights and measures in this country. This system is obligatory in 34 countries, with a population of 437,000,000. In an official report issued by the Government of the United States this year I find the following statement: "Commerce, technology and science have, on account of their international character, availed themselves of the advantages of the metric system more than manufacturing, which is local, and, unlike exporting, not in direct touch with world markets. Hence science and commerce, with their world-wide outlook, should be the advisers of industry, and their conclusion is that the first principle is to supply what the customer needs, and that international business requires international weights and measures." The British Chamber of Commerce at Buenos Ayres in February, 1916, passed the following resolution: "That this Chamber unanimously recommends to the immediate attention of the British authorities the capital necessity of the adoption of the metric system as a very material factor to assist the expansion of Britain's overseas trade after the war."

Is there any reason why we should not be successful in our trade campaign after the war? Over two years ago we entered a war, not of our making, and for which we were not prepared. Under the late Lord Kitchener, an honorary member of this Institution, an army of over 4,000,000 men was organised; under Mr. Lloyd George was organised the manufacture of munitions on a huge scale. Canada, Australia, New Zealand, India, South Africa and the other members of our overseas Empire came to our aid in such numbers as we could never have anticipated. Burke rightly gauged human nature when he wrote: "War is a situation which sets in its full light the value of the hearts of a people."

It is pleasant at times to take an optimistic view, and such views sometimes come true. In a remarkable series of lectures on England and Germany by the late J. A. Cramb, delivered in 1913, a year before war was thought of, he discussed the supposed decay of our Empire, and in the last lecture said:—

"Even now, in 1913, when I consider England and this vast and complex fabric of empire which she has slowly reared, its Colonies, its dependencies, the cosmic energy which everywhere seems to animate the mass in its united life and in the separate States or principalities, all such comparisons with decaying empires appear an irrelevance or a futility. Whatever be England's fate, it will not be the fate of Venice or Byzantium. And as a proof of the validity of this impression, or this conviction, I seem to discover everywhere stirrings as of a new life, to hear the tramp of armies fired by a newer chivalry than that of Crecy, and on the horizon to discern the outline of fleets manned by as heroic a resolve as were those of Nelson or Rodney."

It is a matter of regret that the author did not live to see his anticipations realised.

We cannot engage in a war where men of all classes are fighting shoulder to shoulder without some diminution of the old class prejudices. We cannot fight side by side with our overseas brothers without getting to know each other better, and without realising that we all have to continue after the war to do our best for the Empire with as little internal friction as possible. With such better knowledge of each other, and remembering that unprepared we entered a war in which we are, with our Allies, achieving success, is there any reason why, when fully prepared and in full agreement with our Allies and our overseas Empire, we should not be successful in peace?

Of course I am an optimist, but not one who imagines that what we want can be obtained without fighting and working for it. It may only be the dream of an optimist to imagine that this country can be run for the benefit of our own people, without preconceived views, without ancient shibboleths, without red tape. It may be a dream, but it ought to be a fact.

I am afraid I have gone somewhat beyond the lines I laid down for this address, and my only excuse is that the conditions under which we are living are exceptional, and that it is difficult to keep daily thoughts out of anything we may write or say.

Gentlemen, the greater portion of my address to you to-night may possibly be considered too much out of the common because it deals with some of the very common matters which have to be considered by engineers. My remarks are really reflections on the different events which have occurred during my own life as an engineer, extending now to over 30 years. I hope they at least show that there is still ample room for investigation and experimental work, which may enable us to give still greater value to our clients, and that it may influence young engineers especially to devote some of their time to that class of work whenever opportunity for doing so is present.

American Machinery.—The Inter-Colonial Machinery Corporation has been incorporated at Wilmington, Delaware, with a capital of 500,000 dols., and with head offices in Broadway, New York. The company proposes to deal in machinery in general, but it will specialise in machine tools, both in the United States and foreign countries, and it will establish branch offices in the principal European countries, beginning with Russia.

THE PHYSICAL SOCIETY OF LONDON.

At the meeting held on Friday, October 27, 1916, at the Imperial College of Science, Mr. F. E. Smith, A.R.C.Sc., vice-president, in the chair, a paper entitled *The Application of the Kerr Effect to the Determination of the Saturation Values for Magnetism of Ferro-Magnetic Metals, Compounds and Alloys*, by S. G. Barker, D.I.C., Ph.D., was read, in the absence of the author, by Dr. S. W. J. Smith, F.R.S.

The paper describes work carried out in the laboratory of Professor Du Bois on the relation between the intensity of magnetisation of various ferro-magnetic materials and the rotation of the plane of polarisation of plane polarised light reflected from a polished surface of the material. The specimens, in the form of circular discs 5 mm. in diameter and 0.5 mm. thick, were soldered to one of the pole pieces of a large electro-magnet. Through an aperture in the other pole, monochromatic light, polarised in two nearly coincident planes by means of a Lippich polariser, was incident almost normally on the polished surface of the specimen. The reflected beam passed through an analyser, the rotation of which could be measured, by means of an auxiliary optical system, to a high degree of accuracy.

In the first part of the paper results are given for a number of materials of known magnetic properties in order to establish the validity of the method, due to Du Bois, of obtaining the value of the saturation intensity from the curve connecting field strength with rotation. The method is then applied to materials of unknown properties. The variation of the Kerr constant with the wave-length of the light was also determined for a number of substances.

Mr. D. Owen asked if the paper, in addition to establishing the view that the rotation was proportional to the intensity of magnetisation, brought forward any new results that were useful to theory. For instance, he recollected a paper by B. Hopkinson, in which it was found possible to obtain an intensity of magnetisation greater than that obtainable with pure iron, and he noticed that in the present paper there was an alloy of iron and cobalt which exceeded pure iron in saturation intensity. Was it now taken for granted that it was possible in an alloy to obtain magnetisations greater than that of either component, or were the results in the paper somewhat novel in this respect?

Dr. Smith said that saturation intensities of magnetisation were of importance for various reasons. For instance, as Weiss had shown, it was of theoretical interest to know their temperature variations. Again, in the case of a "mechanical" mixture of two substances, the saturation intensity would be related in a simple manner to those of the constituents. There was much evidence that annealed steels are mixtures of iron and iron carbide. Hadfield and Hopkinson, in the paper which had been mentioned, had shown that the saturation intensities of magnetisation of such steels were compatible with this view, and had deduced a value for the saturation intensity of the carbide. It would have been of interest if Dr. Barker had determined the latter directly, as had been his intention, before the work was interrupted. Alloys were not, however, always simple mixtures. The steel examined by Hopkinson and Hadfield, to which Mr. Owen had referred, was a nickel steel, and its total magnetisation was greater than the sum of those which its constituents would have exhibited separately, although it was not as great as that of pure iron. The reason probably was that nickel-iron alloys formed solid solutions (mixed crystals) instead of mechanical mixtures. The same was probably true of cobalt-iron alloys, although in this case a material could be obtained (possibly a compound) whose saturation magnetisation was actually greater than that of pure iron. It had been proposed to use this alloy commercially. Other solid solutions were known in some of which the magnetisation was greater, and in others less, than that which mechanical mixtures of the components would have exhibited.

A paper entitled *The Influence of the Time Element on the Resistance of a Solid Rectifying Contact* was read by Mr. D. Owen, B.A., B.Sc.

The resistance at a solid rectifying contact, and consequently the exact shape of the resistance characteristic, depends upon the time for which the testing current is allowed to flow. A series of characteristics are given corresponding to durations of contact extending over the range one forty-thousandth of a second to 30 seconds. The following conclusions are drawn:—

1. That the variation of resistance with voltage may be attributed entirely to thermal effects.

2. That the characteristic obtained by applying the testing voltage for one hundredth of a second is, at moderate voltages, materially the same as that which would be found at the expiry of a period of the order of a millionth of a second.

3. That the sensibility of a wireless receiving circuit (in which the rectifying contact is used) does not differ very appreciably from that deduced from a slow period characteristic.

4. That an important fraction of the contact-resistance resides in a stratum of molecular thickness at the interface of the two elements of the contact; and that it is in this region alone that rectifying action at very high frequencies is effected.

Professor G. W. O. Howe thought the experimental method of Mr. Owen was the correct way to tackle the problem of high-frequency phenomena, and was preferable to taking oscillograph records at low commercial frequencies, and attempting to deduce from them what will happen at very much higher frequencies. What was the limit to the number of times per second that the ball may be struck for the results still to apply to one impact only? From one point of view the results were disappointing, inasmuch as it had been necessary to

ntroduce a mysterious stratum of molecular thickness and the problem arose as to what these layers consisted of; what were their properties, and why was the thermal effect largely confined to them?

Dr. H. S. Allen asked if any attempt had been made to remove surface films from the contacts. Professor Millikan had recently obtained very simple results in photo-electricity by working in a high vacuum, so as to remove all films of moisture. Could this not be done in Mr. Owen's experiments?

Dr. Eccles said that the subject of contact resistance was of wide importance, apart from its application to electric wave detectors. It had been investigated by Wheatstone and Heaviside in other connections—microphones, for example. It was important also in connection with the contacts at dynamo brushes. There had always been a desire in wireless telegraphy circles for high-frequency characteristic curves. Doubtless, if oscillograph records could be obtained for frequencies of 10^{-6} second, they would be very like what Mr. Owen got by his point to point method. He would have been glad if the author had tried similar contacts—*e.g.*, two carbons, two galenas, or even two metals. In these cases there would be no thermo-electric phenomena to confuse the issue. He was not convinced on the question of the molecular layer. The author stated that "in actual practice the mean diameter of the area of a good rectifying contact is, as a rule, far greater than 10^{-4} cm." Now, if one pictured a piece of metal resting on the zigzag surface of a crystal, it was obvious that actual contact would only occur at points and ridges, and it was surely impossible for anyone to assert what the order of the area of contact was. He preferred to think that the effects were due to the heating of the surface layers of the stuff, due to concentration of the current flow into the narrow regions where actual contact existed. Usually, the harder the crystal the better the rectification obtained, due possibly to the greater concentration of current in the smaller and sharper contact points. He thought perhaps too much stress was laid on the high-frequency characteristic. When an oscillation passed through the contact of a crystal touching a metal plate it was the after-effects of the heat developed which produced the thermo-electric currents that affected the telephone. Therefore, while of scientific interest, the high-frequency characteristics were not very essential from the point of view of wireless telegraphy.

Mr. F. E. Smith thought Dr. Allen's suggestion a valuable one. About 14 years ago a paper was read to the society showing that films of liquid remained attached to solids even up to temperatures of 300 deg. C.

Mr. Owen, in reply to Professor Howe, thought there was no mystery connected with the contact layer. We could not assume complete continuity of material at a contact, as in a weld, since there was never any difficulty in pulling the elements apart. With respect to the repeated impacts, the time between the impacts was never less than about 8,000 times the duration of contact. The point raised by Dr. Allen required investigation. It was scarcely necessary for him to reply to most of Dr. Eccles' remarks, as they really constituted an independent contribution to the subject.

On account of the lateness of the hour, Mr. B. W. Clack kindly agreed to postpone the reading of his paper *On Diffusion in Liquids* until the next meeting.

THE IRON INDUSTRY OF UPPER SILESIA.—The half-yearly report of the Upper Silesian Iron Industry Company points to very satisfactory profits; the company is fully employed, and there are no signs of approaching slackness. The absorption by the Upper Silesian Iron Industry Company of the Julien Hütte steel works has now been completed. Also other industrial undertakings in the same district are sending out encouraging reports; they all seem fully employed for six months or more at satisfactory prices, and even orders at special quotations are being refused. Stocks are very low and old stocks have in many cases been advantageously disposed of. The Upper Silesian Railway Requirements Company expects to turn over 135,000,000 marks before the end of the year; the financial position is eminently satisfactory, and the purchase of the Jackmann concern gave no trouble, although it entailed an outlay of 6,000,000 marks. The Bismarck Hütte has issued a very satisfactory balance sheet; with a share capital of 16,000,000 marks there is a war loan and bank credit aggregate of 17,280,000 marks, and the regular reserve amounts to 50 per cent. of the share capital, without counting reserves in ore deposits, &c.

CONTINENTAL SHIPBUILDING DIFFICULTIES.—Although the shipbuilding industry never has experienced such a busy time as at present, there are difficulties of diverse kinds which have to be faced, and which apply both to the yards and their customers. Thus Norway has at present some 30 to 40 shipbuilding contracts with Dutch yards, but even if the vessels can be completed at the stipulated time, various considerations may jeopardise the actual delivery. There is just at present a case illustrating this; the vessel in question is ready, but the Dutch Government hesitates to let it leave Holland, as it may have been built with "classed" material, not to be re-exported, and perhaps hailing from both England and Germany. These, of course, are temporary difficulties, which, however disagreeable for the time being, will be got over. But serious apprehension is felt as to the future of the new yards. Materials and machine tools are expensive and hard to get. Skilled engineers and skilled labour offer still greater difficulties. The old yards cannot get the hands they require, and the question as to how the new establishments are to be supplied remains unsolved. Shipping conditions are not unlikely to have lost a little of their present boom before the difficulties can be met.

PROCEDURE AFFECTING SUPPLIES OF MATERIALS.

WE have received the following official communication:—The Ministry of Munitions is desirous of informing manufacturers, merchants and exporters that the arrangements that have been in force for controlling supplies of steel, tinplates, &c., are to be extended to other materials, and for the convenience of the public an explanation of the above-mentioned arrangements and their extended application is set forth below. To obtain, whether for home use or export, supplies of copper wire, cable containing copper, Bessemer and open-hearth steel, corrugated sheets, tinplates, tinned sheets, terne plates, blackplates and lead-coated sheets, it will be necessary either to quote a Government contract reference and number if the materials are required to execute a Government contract or to procure a permit reference number and priority classification from the Ministry of Munitions, Priority Branch, 28, Northumberland-avenue, W.C. In applying for such a permit, full particulars of the requirements and purpose should be given. This Government contract reference and number or permit reference and number and priority classification, as the case may be, must be quoted to the suppliers, who are forbidden to deliver any of the aforesaid materials without being furnished with a Government contract number or reference number and priority classification covering the material ordered.

Where one of the following can be quoted to the suppliers no permit reference number and priority classification from the Ministry of Munitions are needed:—(1) Admiralty contract reference and number or Admiralty Priority Section permit reference and number. (2) War Office contract reference and number. (3) Ministry of Munitions contract reference and number. (4) Commission Internationale de Ravitaillement or Commission Française sanction reference and number, with Ministry of Munitions priority classification. (5) Board of Trade (Marine Department) (in the case of mild steel only) permit reference and number declaring merchant shipping to be munition work. (6) Post Office contract reference and number (in the case of copper or copper alloys only). In the above cases (1–6), suppliers, on receipt of the contract or permit reference number and a declaration by the customer that the materials ordered are required solely to fulfil the orders covered by the reference number quoted, are entitled to deliver on the basis of priority classification A/4 (War Work). If a higher grade of priority is required, application must be made to the Priority Branch of the Ministry of Munitions, stating the ground of special urgency.

The reference, date and grade of contract permit or priority classification should be passed on to sub-contractors, if any, so that they, like the main contractor, can quote the necessary particulars referred to above on any orders that may be placed with the merchant, stockholder or the manufacturer of the materials. This means that once a permit has been granted for a certain plant, such permit covers all parts and materials necessary for completing the plant unless instructions to the contrary are entered on the original permit. As a general rule the customer should make the application for permit and priority classification, and not the stockholder or manufacturer of the materials. References need not be insisted upon in the case of urgent Admiralty telegraphic instructions for immediate repairs to ships.

In cases of machine-tool firms and electrical firms the order can be covered by quotation of the reference and date of permit accorded by the Machine-Tool Department or Electrical Branch of the Ministry of Munitions respectively, for the machinery or parts for which the material is ordered.

None of the aforesaid materials can be supplied, except for orders or contracts coming within Class "A" or Class "B"; only shell-discard quality steel and iron are allowed to be supplied in Class "C" or Class "C," Priority Instruction 6. If required for use within the United Kingdom, shell-discard quality steel can be obtained without any permit. If for export, shell-discard quality steel can be obtained only where the orders have been classified by the Priority Branch, and the reference number of the classification certificate and specific particulars of destination must be quoted to suppliers and the War Trade Department.

In all applications full particulars should be given under the following headings:—(1) A precise description of the articles or materials required. (2) The exact quantities thereof. If required for different orders or purposes, the quantities required for each order or purpose respectively. If required for stock or "running account," the minimum quantities needed for a period of three months and the respective quantities in hand at present. (3) The name of the firm or firms with whom the order or orders are or are to be placed respectively. (4) The respective war, national or other object to be served, and proof of urgency and importance. A priority certificate is required even though the goods are merely to be transferred from one branch of a firm in the United Kingdom to another branch of the same firm in a foreign country or British possession. Merchants, manufacturers and the general public are earnestly requested to assist the Ministry of Munitions in particular and the nation in general by refraining from applying for permission to obtain the materials mentioned herein unless the same are required for war or other urgent national objects. It is essential that supplies should be conserved for direct war work and work of urgent national importance.

Notice in Regard to the Export.

With a view to conserving supplies of copper wire or cable, Bessemer and open-hearth steel, corrugated sheets, tinplates, terne plates, blackplates, tinned sheets and lead-coated sheets, the Director of the War Trade Department announces that it has been arranged with the Ministry of Munitions that export licences will not be granted unless a Ministry of Munitions priority certificate (Class "A" or Class "B") permitting manufacture or sale from stock has been obtained, or unless the reference and number of an Admiralty contract or permit or War Office contract for the completion of which the copper wire or cable, steel, tinplates, &c., are required can be quoted. Export licences will not, as a general rule, be issued in respect of copper wire or cable, steel, tinplates, &c., for which a Class "C" certificate is quoted.

In the case of allied countries (France, Russia, Italy, Serbia, Portugal, Roumania, Belgium, Japan) priority certificates are only given in very exceptional cases by the Ministry of Munitions unless the application is supported by the Commission Internationale de Ravitaillement, whether the consignment is intended for a Government contract or not. Application should, therefore, be made direct to the Commission Internationale de Ravitaillement, India House, Kingsway, London, W.C., which, if prepared to support the case, will communicate with the Ministry of Munitions, and arrange for the issue of a priority certificate. If the copper wire or cable, steel, tinplates, &c., are for Government work and export is allowed, the permits for export will be issued by the Commission Internationale de Ravitaillement. If the goods are not for Government work and the applicant is in a position to quote a priority certificate ("A" or "B") or contract reference and number, he should make an application to the War Trade Department for the grant of an export licence, and if the export is allowed a licence will be granted by that Department.

In the case of Sweden, Norway, Denmark, Holland and Switzerland, application should be made in the first instance to the War Trade Department, which, if there is no immediate reason for refusal, will arrange direct with the Ministry of Munitions for the issue of a priority certificate. The applicant should not communicate direct with the Ministry of Munitions, and the priority certificate will be forwarded to the applicant by the War Trade Department with the export licence. This exception does not apply to Bessemer and open-hearth steel nor to corrugated sheets.

In the case of all other destinations, including British possessions, application for a priority certificate should be made direct to the Ministry of Munitions, Priority Branch, 28, Northumberland-avenue, S.W. No application for an export licence can be considered by the War Trade Department unless the number of a Ministry of Munitions priority certificate under Class "A" or Class "B" (or alternatively an Admiralty or War Office contract number) is quoted.

A priority certificate is required even though the goods are already manufactured, and even though the goods are merely to be transferred from one branch of a firm in the United Kingdom to another branch of the same firm in a foreign country or British possession. Applicants are warned that the issue of a priority certificate by the Ministry of Munitions is not a guarantee that an export licence will be issued by the War Trade Department. If exporters have any doubt as to the reliability of the proposed consignee, they are recommended, before proceeding to manufacture, to consult the War Trade Intelligence Department, Broadway House, Tothill-street, S.W. (as regards foreign countries in Europe), and the Foreign Trade Department, Lancaster House, The Mall, S.W. (as regards foreign countries outside Europe).

TAR OILS AS FUEL FOR DIESEL ENGINES.—At the meeting on October 20 of the Diesel Engine Users' Association, Mr. Napier Prentice gave further information in connection with the application which had been made by the Suffolk Electricity Supply Company, Limited, for the voidance or suspension for the duration of the war of the Konrad Aust patent in connection with the use of tar oils as fuel in Diesel engines. He considered that on national grounds such action should have been urged or supported by a Government department. Since the application had been made, however, his experience in the use of tar oils in Diesel engines without the fitting of any pilot ignition apparatus had been so satisfactory that he did not think it would be advisable that his company should incur any costs in connection with the adoption of the method of working covered by the patent. He was now effecting a saving of about 50 per cent. in fuel costs by the partial use of tar oil. Mr. Geoffrey Porter (president) gave particulars concerning a pilot ignition apparatus which had been fitted to a Diesel engine at Worthing. The saving in fuel costs obtained by using tar oil in this manner with about 10 per cent. of crude oil for the ignition charge amounted up to date to about 47 per cent. The only trouble experienced had been in connection with the formation of a deposit which choked the pulverisers. No trouble had been experienced with the exhaust valves or with the needle valves. He also stated that he had tried on another engine a mixture of three parts of tar oil to one of crude oil. The engine had knocked rather heavily, but at three-quarters of full load, and with fairly continuous running, no further troubles had been experienced. He, however, did not favour the use of mixtures of tar oil and crude oil. There was some risk of mis-firing, and there was a difficulty in securing complete mixture of the two classes of fuel oil. Mr. W. A. Turnbull stated that he had worked a Diesel engine on tar oil with a slight alteration to the flame-plates, and he had obtained a saving of about 50 per cent. in fuel costs. He had not noticed any corrosive effect by the tar oil on the copper pipes or brass fittings.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

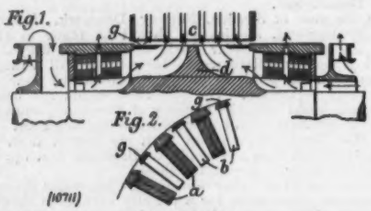
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

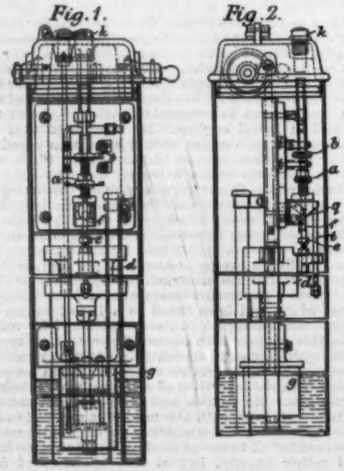
ELECTRICAL APPARATUS.

10,711/15. A. Mond, London (*Maschinenfabrik Oerlikon, Oerlikon, Switzerland*). **Ventilating Dynamo Electric Machines.** (6 *Figs.*) July 23, 1915.—The rotor, which is toothed in a uniform or practically uniform manner, is provided around its periphery with slots or passages which serve two different purposes. The slots *a* house the excitation winding, and the slots *b* are used for cooling. These slots, however, not only conduct the cooling air, but also, at the same time, generate the whole or part of the pressure necessary to force the cooling air through the slots themselves. Large radial openings or outlets *c* are provided near the centre of the rotor, the radial walls of which openings cause them, when the rotor is running, to act as a powerful radial fan which forces the cooling air through



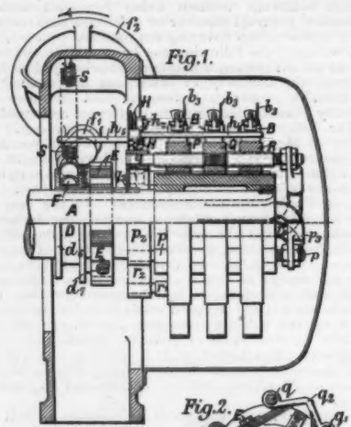
the openings *c* into the air space between the rotor and the stator, and thence through the stator ventilating slots. In contrast to the winding slots, the cooling or ventilating slots are not continued right through the entire radial length; but a bridge *d* is provided in the centre of the opening *c* to serve as a lateral stay for the rotor teeth in the places where the latter are not held by wedges. The cooling slots are closed at their upper ends at those portions of their length where there are no radial outlets for the cooling air, preferably by wedges *g* of magnetic material forced into the slots. The cooling slots *b* are made of a radial depth approximately that of the winding slots *a*, giving rise to increased magnetic saturation at the roots of the rotor teeth and producing a strong curvature of the no-load characteristic of the machine. (*Accepted August* 9, 1916.)

11,603/15. Thomas Broadbent and Sons, Limited, Huddersfield, The British Thomson-Houston Company, Limited, London, and W. L. Wise, Rugby. Control of Electric Motors. (4 *Figs.*) August 11, 1915.—A starting switch *a* and a retaining switch *b* are mounted upon a common spindle and operated by a weight *d*, so that when the weight is lifted to the top of its travel a projection *e* carried by the weight closes both switches. A catch *f* on the spindle of the switches is engaged by a pivoted stop *g* which is pressed into position under the catch by the action of a spring and is released by a downward movement of the tappet rod *t*. The engagement of the catch *f* with the sto pholds the retaining switch *b* closed during the



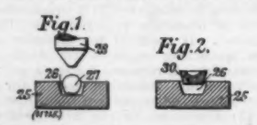
descent of the weight which, on nearing the bottom of its travel, carries with it the tappet rod *f*, thereby releasing the catch and allowing the switch to open. The rate at which the weight descends is controlled by a dash-pot *g* provided with an adjustable needle valve whereby the time taken by the weight to descend may be varied. A press button switch *k* may also be provided for opening the retaining switch to stop the motor in case of emergency. When the weight is raised, both the starting and retaining switches are closed and the motor circuit completed. The springs on which the bridging members of these switches are carried are so arranged that when the weight begins to descend the spindle on which the switches are carried also descends for a short distance before the catch *f* is engaged and held and the starting switch is opened. This is accomplished by providing the starting switch with a larger closing gap than the retaining switch. Before the starting switch opens, however, the motor circuit has been completed and transferred to the retaining switch. On reaching the limit of its downward travel the weight releases the catch and allows the retaining switch to open. (*Accepted August* 9, 1916.)

11,790/15. The Lancashire Dynamo and Motor Company, Limited, Manchester, H. B. Whitmore, Stockport, and J. R. Roberts, Manchester. Brush Gear. (8 *Figs.*) August 16, 1915.—This invention relates to short-circuiting devices for alternating-current motors. The sleeve D slides on the shaft A and is caused to rotate therewith; a ball pressed by a spring serves, by engagement with notches, to hold the sleeve in one or other of its two limiting positions; the sleeve carries the three tangentially-arranged brushes E, which are secured in position by being bolted on to facings d^6. The sleeve is provided with a groove between the two flanges d^6 and d^7 and the crank-pin F of the crank-shaft f^1 is adapted to engage in this groove. The crankshaft is journalled in a bearing formed in the casing G and passes out through the casing and is fitted with a handwheel f^2. The crank-pin is connected by a spiral spring *s* to a bracket in the casing, the position of the bracket being so located that the initially-stretched spring tends to hold the crank in one or other of its two extreme positions, the line of action of the spring passing the dead centre of the crank between these positions. The slip-ring brushes B are adapted to be lifted clear of the slip-rings



P, Q, R by the tail pin A^5 carried by the lever H fulcrumed on the pivot H^2 carried by the casing; the lever H is fitted with an adjustable stop pin, and a spring tends to maintain the lever in the limiting position determined by the stop. The lever also carries a second tail pin A^1, which extends underneath the extensions b^5 of the slip-ring brush fingers. The axes of the tail pins A^1 and A^5, and the pivot pin A^2 lie parallel with the axis of the motor shaft A. On turning the handwheel in one direction the crank-pin F engages the flange d^7 and slides the sleeve D axially until the three brushes E slide into engaging contact with contact plates p^2, q^2 and r^2, and so short-circuit the windings p^3, q^3 and r^3 through the bars *p*, p^1, *q*, q^1 and *r*, r^1. The leading edges of the plates are bevelled to allow the brushes to slide freely into position. Further angular movement of the crank after it has effected the movement of the sleeve D causes the crank to move out of the groove and to engage with the tail pin A^5 and impart angular movement to the lever H. The lever H raises the tail pin A^1, which engages with the extensions b^5 and raises the several pairs of brushes till the latter are clear of the slip-rings. (*Accepted August* 16, 1916.)

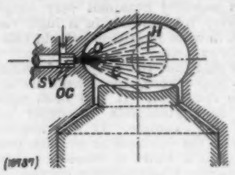
11,715/15. The British Thomson-Houston Company, Limited, London (*General Electric Company, Schenectady, U.S.A.*). **Electrical Measuring Instruments.** (2 *Figs.*) August 13, 1915.—The invention relates to jewel bearings for electrical measuring instruments. In Fig. 1 there is represented a block 25 of a suitable material, for example, carbon, which will withstand considerable heat. The block 25 has a recess 26 in which is placed a bead 27 of quartz, glass or other fusible material



of satisfactory hardness. The block 25 and the bead 27 are heated until the quartz becomes plastic, when a die 28 is forced into the plastic mass, resulting in a perfectly formed "jewel." It will, of course, be understood that the die 28 is shaped to produce exactly the desired configuration of the bearing surface of the "jewel" when pressed into the plastic bead 27. The recess 26 has a tapered wall, so that the finished "jewel" 30 can be withdrawn, as illustrated in Fig. 2 of the drawing. (*Accepted August* 16, 1916.)

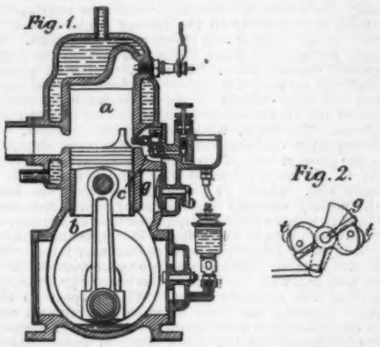
GAS-ENGINES, PRODUCERS, HOLDERS, &c.

10,787/15. Sir K. I. Crossley, Manchester, and W. L. P. Webb, Hale. Oil Engines. (4 *Figs.*) July 26, 1915.—This invention relates to oil engines which use the heavier fuel oils and in which the oil is injected by itself as spray into the compressed, and therefore heated, air in the combustion chamber towards the end of the compression stroke, the air being compressed, and therefore heated, to such a degree that when the oil is sprayed into the combustion chamber it is ignited. S, V is the oil sprayer valve and O the spraying orifice. C is the combustion chamber, which is of elongated and somewhat oviform shape. The hottest core or zone during spraying is indicated approximately by the space contained within the dotted lines at H. The shape of the combustion chamber tends to prevent the hottest zone or core being so adversely affected by the cooling



action of the entering oil spray as to be moved unduly near and be unduly affected by the cooling influence of the cold walls enclosing the end of the chamber opposite to the oil sprayer, as this might thus tend to lower the temperature of the hottest zone to such an extent as to be insufficient to effect ignition satisfactorily. (*Accepted August* 9, 1916.)

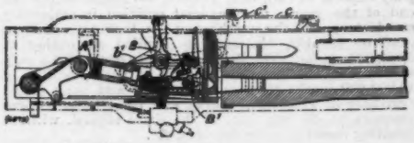
10,699/15. E. W. Petter, Yeovil. Two-Cycle Oil Engines. (3 *Figs.*) July 23, 1915.—According to this invention, a cam-shaped valve *g* is placed in the air passage *c* between the crank case *b* and the cylinder *a* and oscillated under the action of the governor to cover and uncover a port. The curve of the periphery of the valve is first steep, so as to rapidly cover the port during the first part of its movement, the steep part being followed by rather a flat curve, so that the port holes are allowed to remain unaltered by the action of the governor for a certain further range of movement, this portion being followed by a sudden rise or steep curve which completely covers the port holes when the speed reaches a certain predetermined velocity.



When the engine is at rest the port holes *t* are fully open. When the engine is started the engine governor causes the cam-shaped valve to be moved on its axis, so that when the engine reaches its normal speed the cam-shaped valve commences to cover the port holes, and immediately the speed increases the port holes become nearly covered by the effect of the steep curve of the periphery of the valve, leaving only a comparatively small opening. The port holes are allowed to remain unaltered by the action of the governor for a certain further range of movement, which is effected by the flat curve following the steep curve. Finally the speed reaches a point when the cam-shaped valve completely covers the port holes, due to the sudden or steep curve of the valve. (*Accepted August* 9, 1916.)

GUNS AND EXPLOSIVES

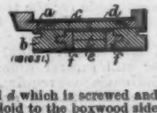
6,875/15. Vickers, Limited, and G. T. Buckham, London. Automatic Guns. (2 *Figs.*) May 7, 1915.—According to this invention, the cover of the gun mechanism casing *c* is provided with a tripping piece c^1 against which a tumbler B comes during the rearward travel of the lock A, to displace the tumbler and cock the striker B^1, the tumbler having



an arm b^1 by which it can also be displaced by the connecting rod A^2 to cock the striker in the usual manner when the lock is operated by hand with the cover open. The tumbler may be provided with an upwardly-projecting extension for engagement with the aforesaid tripping piece C^1 on the cover. (*Accepted August* 16, 1916.)

MISCELLANEOUS.

101,051. John Davis and Son (Derby), Limited, and W. H. Davis, Derby. Slide Rules. (1 *Fig.*) February 16, 1916.—The body of the rule is formed with a mahogany foundation *a* and the sides *b* of boxwood glued and pinned to the mahogany base. The sides are connected by a piece of celluloid *c*



and a strip of metal *d* which is screwed and pinned through the mahogany and celluloid to the boxwood sides; this combination ensures elasticity. The slide rule of the rule is constructed in the centre of mahogany built up in longitudinal strips or layers *e*, and has boxwood sides *f*, the whole is covered top and bottom with celluloid. (*Accepted August* 16, 1916.)